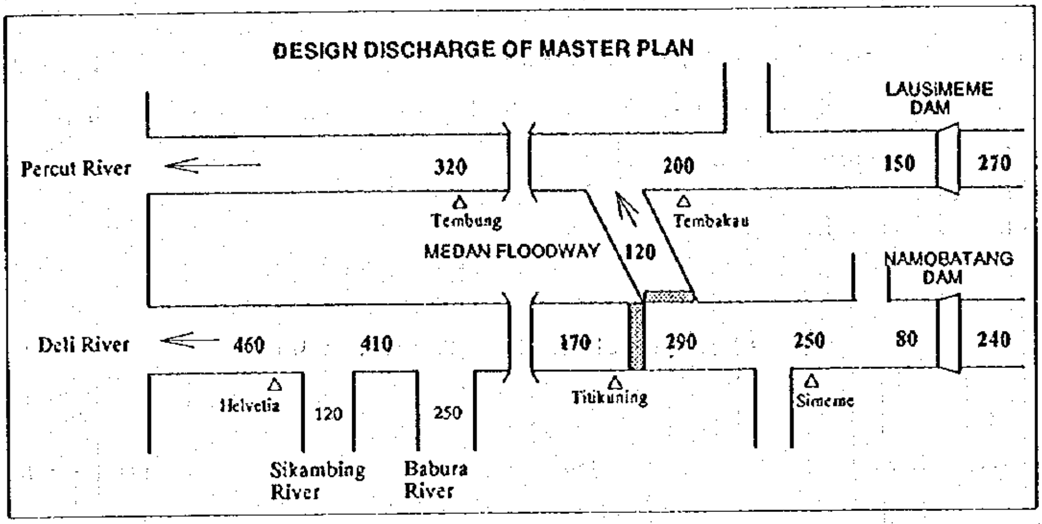


4.1.3 Project Works

The project works covered by the D/D Study are formulated in accordance with the Immediate Plan. The works are divided into three (3) components, as follows:

(1) Percut River Improvement Works;

(2) Construction of Medan Floodway and Diversion Weirs; and

(3) Diversion and Improvement Works of Upper Deli River.

These project works are designed to meet the requirements of not only the Immediate Plan but also the Urgent Plan. The major works of each component are shown in Fig. 4.1.1 and described below.

(1) Percut River Improvement Works

Aiming at increasing the flow capacity of the channel, Percut River will be improved for the channel stretch of about 28.0 km (from the river mouth to the junction with Medan Floodway). All river structures including bridges to be affected by the river improvement works shall be reconstructed to maintain the existing function of such structures.

The river improvement works is divided into two portions: the downstream stretch from the existing Titi Runtuh Bridge (P13.2K) to the river mouth, and the upper reaches from the bridge to the confluence with Medan Floodway. The river improvement shall include the following major works.

(a) Downstream Stretch from Titi Runtuh Bridge

Project Works	Quantity
Dike Construction including Reinforcement of Existing Dikes	13,150 m
Channel Excavation and Dredging	13,150 m
Improvement of Lalang River	1,241 m
Construction of River Structures	
- Low Water Revetment	2,320 m
- Dike	2,420 m
- Groin	9 sites
- Groundsill	1 site
- Approach Step	65 sites
- Jetty and Landing	1 site
Reinstallation/Reconstruction of Existing Drainage Outlet	2 sites
Relocation of Drainage Channel	710 m
Relocation of Bandar Sidoras Intake Weir	1 site
Reconstruction of Bridge and Approach Road	3 sites
Relocation of Kabupaten Road	1,985 m
Relocation of Farm Road	2,170 m
Installation of Intake Gate for Fishpond	2 sites

(b) Upstream Stretch from Titi Runtuh Bridge

Project Works	Quantity
Channel Widening and Straightening	15,100 m
Riverbank Protection (Wet Masonry Revetment)	3,300 m
Construction of River Structures (Approach Step)	53 sites
Bridge Protection Works	4 sites
Reinstallation of Existing Drainage Outlet	35 sites
Reconstruction of Bridge and Approach Road	6 sites
Reconstruction of Water Pipe Bridge	1 site
Relocation of Water Level Gauging Station	1 site

(2) Construction of Medan Floodway and Diversion Weirs

The floodway and diversion weirs shall serve for diverting a part of the flood of Upper Deli River into Percut River. The floodway is designed as an open channel with a total length of about 3,900 m connecting Deli River and Percut River. To control the flood discharge in the downstream of Deli River and to divert a part of the flood into the floodway, diversion weirs will be constructed at the Deli River Channel (Deli River Weir) and at the entrance of the floodway (Floodway Weir). The related works are as follows;

Project Works	Quantity
Excavation of Foodway	3,920 m
Revetment (Wet Stone Masonry)	2,585 m
Revetment (Retaining Wall)	1,035 m
Construction of Groundsill (at junction)	1 site
Construction of Drainage Channel/Ditch	7,020 m
Construction of Drainage Outlet	7 sites
Construction of Bridges (Road / Railway / Water Pipe / Pedestrian)	10 sites
Construction of Inspection Road and Tree Planting	7,600 m
Partial Improvement of Batuan River	100 m

(3) Diversion and Improvement Works of Upper Deli River

The retarding channel situated upstream of Deli River Weir will be improved to smoothen flood flows for the effective diversion of discharge and to create a space with better scenery and amenity for inhabitants therearound. The related works are as follows;

Project Works	Quantity
Construction of Deli River Weir	1 site
Construction of Floodway Weir	1 site
Excavation of Embankment of Retarding Channel	830 m
Revetment	700 m
Construction of Pedestrian Bridge	1 site
Construction of Walkway	2,100 m
Tree Planting	650 m
Approach Step	7 sites

4.2 Basic Design

Design criteria are prepared to serve the structural and hydraulic design of river improvement works and flood control structures for the Project. The basic concepts and procedures for the planning and designing are based mainly on the "Flood Control Manual" prepared by the Ministry of Public Works, Government of Indonesia; the "Technical Standard of River and Sabo" by the Ministry of Construction, Government of Japan; and the results of the hydrologic, topographic and geotechnical surveys.

4.2.1 River Improvement

The basic design for the river channels of Percut River, Medan Floodway and Upper Deli River is prepared in accordance with the design conditions discussed below.

Percut River

(1) Alignment

The design alignment of the river course has less meandering to provide a smooth flood flow, while it shall conform with the existing alignment as much as possible. A cutoff channel is, in principle, not employed because of the difficulty of land acquisition in the urban area. In the smoothing and widening of meanders, the following criteria are applied:

(a) At bending sections, the alignment of the channel bank top in the convex side is set back by 10 to 30% of the standard channel width, depending on the degree of bend;

(b) Channel widening in house-congested areas is avoided as much as possible to reduce the number of houses to be evacuated; and

(c) The maximum allowable degree of curvature of the channel (curve radius from centerline) is at least 7 times the water surface width.

(d) At the confluence and effluence of the drainage ditch and small tributaries, proper countermeasures should be provided for protection against backwater effect of the main river.

(2) Longitudinal Profile

The longitudinal profile is shown in Fig. 4.2.1.

(a) Design Riverbed

The design riverbed profile primarily follows the existing average riverbed profile to avoid imbalanced scouring and sedimentation, as well as to minimize relocation and modification of the existing river structures. The ratio of riverbed gradient between the upper and lower stretches is basically set at less than 1 : 2 to ensure the stability of the river channel. For the sections of river structures, the height of design riverbed is determined in relation with the design riverbed slope and the design high water level, considering the intake water level for irrigation, the foundation height of important river structures and so on.

(b) Design High Water Level

The design high water level is, in principle, not higher than the predominant elevation of the adjoining ground or the existing dike. In addition, the height of proposed dike is set within about 3.0 m to minimize the damage potential. The design high water level is determined based on the hydraulic calculation mentioned in the following section.

(3) Cross Section

Standard cross sections along the improvement stretch are presented in Fig. 4.2.2.

(a) Channel Cross Section

A wide and compound cross section with high and low water channels is primarily employed for the lower reaches of Percut River to ensure channel stability and to minimize dike height. On the other hand, single trapezoidal section without diking is applied for the upper reaches located in urban area in accordance with the comparative study on the two alternatives (refer to Table 4.2.1). For slope stability, a small berm with a width of 1.5 m is provided for the above single trapezoidal cross section.

(b) Side Slope

A side slope of 1 : 2 (vertical to horizontal) is adopted for the low water channel to ensure bank stability.

(c) Cross Section at Bending Portion

At bending sections of a river channel, rises in water level and sediment deposit are unavoidable phenomena. Using the hydraulic parameters of the standard cross section and a curve radius of 40 m, the maximum super-elevation of flow at a bend is estimated to be about 50 cm. To lower the raised water level up to the design high water level, the flow area of the channel is increased by setting back the channel bank in the convex side by about 60% of the standard channel width, as shown in Fig. 4.2.3.

Medan Floodway

(1) Justification of Floodway Route

In the B-P Study, a comparative study on route and type of floodway was made to decide the optimum plan. As a result, the optimum plan selected is the trapezoid-shaped open channel starting from Titi Kuning and joining Percut River at the immediate upstream portion of the national road.

To justify the proposed floodway route, a further comparative study was made under the condition of current land use in the proposed area. Three (3) alternatives of floodway route (refer to Fig. 4.2.4) were compared in terms of construction cost (refer to Table 4.2.2), and the Route B proposed by the F/S was proven as the most adequate floodway route even under the current condition of the area.

(2) Alignment

The alignment is almost the same as the one proposed by the B-P Study. Only minor modifications are made in the downstream alignment of the diversion weir (shifted to northern side) and in the middle stretch (shifted to the southern side) to avoid the difficulty of compensation.

(3) Longitudinal Profile

The longitudinal profile of the floodway channel is set, considering the successful diversion of discharge as designed and also the smooth confluence with Percut River, as shown in Fig. 4.2.5.

The water level for the discharges of the Immediate Plan and the Urgent Plan was calculated by using the above modified channel bed. The results are summarized as follows:

(Unit: EL m)

Section	Ground Elevation (Channel Center)	HWL in D/D Study	
		Immediate ($Q = 70\ m^3/s$)	Urgent ($Q = 120\ m^3/s$)
MF 0.000	32.00	30.98	30.52
MF 1.000	39.50	31.08	30.97
MF 2.000	37.00	31.23	31.42
MF 3.000	39.50	31.42	31.85
MF 3.840	38.00	31.64	32.29

The above results show that the design discharge of both the Immediate Plan and the Urgent Plan can safely flow down to Percut River with a high water level lower than the existing ground elevation. Thus, the high water level was determined based on the Urgent Plan.

(4) Cross Section

Since the elevation of the bank top with a freeboard of 0.5 m above the high water level is lower than the existing ground elevation, the crown top is designed as the maintenance road 3.0 m in width. Cross section is a single trapezoidal section having a bottom width of 5.0 m and a side slope of 1 : 1.5 (vertical to horizontal) with revetment.

Since the upper stretch of the Floodway (FW29 to Floodway Weir) is located in the congested urban area with many houses/buildings and a dense road/railway network, a double trapezoidal cross section with a smaller channel width is employed for the stretch. Standard cross sections of a single trapezoidal (Type A) and a double trapezoidal are presented in Fig. 4.2.6.

Upper Deli River

In the upstream of Deli River Weir which will be constructed at UD12, the backwater effect will cause the rising of flood water level. Channel improvement is made only in the immediate upstream side of Deli River Weir (from UD12 to UD23 of about 850 m) by providing embankment on the right bank and by raising the elevation with earthfill on the high water channel (retarding channel) on the left bank.

The upstream from UD23 is affected by backwater, but no protection works are provided since the water level of the design discharge is lower than the ground elevation thercaround. Some protection dikes have been constructed in the area between the Floodway Weir and the Deli River Weir, as well as the area in the right side of the Floodway Weir.

The retarding channel located upstream of the diversion weir is a vacant space at present. Therefore, the channel has a high potential for utilization as a multipurpose area for waterfront activities, park, sports, etc., during non-flood seasons.

The longitudinal profile is shown in Fig. 4.2.7 and the standard cross section is in Fig. 4.2.8.

4.2.2 Riparian Structures

Described in this section are the design conditions for river structures and their features in the Project.

Dike

The standard design sections of river dikes are determined according to the design flood discharge, as stipulated in the "Flood Control Manual." The standard design cross section obtained is shown in Fig. 4.2.9.

In the lower reach of Percut River, the existing dikes are reinforced by heightening and enlarging based on the river improvement plan. As for the area with no diking system, a new dike is built. For the upper reach, small scale embankment to be used for inspection road is proposed on both riverbanks. Furthermore, new dikes are proposed for the improvement of the retarding channel in the Upper Deli River.

(1) Type of Dike

The dikes along Percut River and the retarding channel are made of earth materials excavated from the river channel. The excavated materials, except those in the downstream from the Bandar Sidoras Weir, are found suitable for dike embankment from the geotechnical survey results. In heightening and enlarging the existing dikes, embankment is made on the land-side slope of dike whose surface is stripped by 25 cm thick as shown in Fig. 4.2.10.

(a) Crown Width

The river dike should have an adequate crown width to ensure stability against seepage and piping failure, and to serve as maintenance road for flood fighting activities, daily inspection and so on. In accordance with the "Flood Control Manual," a crown width of 3.0 m is applied to the dike of river whose design discharge is less than 500 m^3/s.

(b) Side Slope

A slope gradient of 1 : 2 (vertical to horizontal) is adopted for both landside and riverside slopes to attain slope stability during flood events and to prevent erosion of slope surface by rainfall.

(c) Freeboard

Freeboard is provided to offset overtopping of floods caused by wave run-up or set-up, super-elevation of flow at a bend, potential dike settlement, crown deterioration and so on. A freeboard of 0.8 m is employed for the dike of Percut River and the retarding channel upstream of Deli River Weir. This freeboard corresponds to the discharges of between 200 m^3/s and 500 m^3/s according to the "Flood Control Manual," while it is 0.5 m for less than 200 m^3/s.

(2) Stability of Embankment

The following criteria are applied to ensure the stability and satisfactory functioning of the dike:

(a) The embankment and its foundation shall be stable. They shall not deform excessively under any load which may occur during construction or service life, including seismic load.

(b) The side slopes of the dike shall be so designed to resist erosion during normal river flows, rainfall and flood events.

(c) Seepage through the embankment shall be controlled to prevent excessive uplift, piping, instability, sloughing and erosion.

(d) The crown of dike shall be made with a camber to allow for settlement during its life.

(e) Extra embankment shall be provided to cope with the settlement of earth dike body and consolidation of subsurface layer after construction so as to keep the design dike crown elevations. The extra embankment shall be so designed to increase the height of dike by 10%. In case a large settlement is anticipated due to consolidation, the extra embankment shall be determined based on the calculation results of settlement.

(3) Others

Inspection roads are provided on the dike crown for river patrol and flood fighting activities. These roads are paved with gravel, 2.5 m wide. Ditches are provided along the dikes to collect rainwater from dike slopes.

Approach roads/steps are provided on both land and river sides at an interval of about 1.0 km for the purpose of maintenance work on dikes, flood fighting activities and daily passage of nearby residents.

Slope and Riverbed Protection Works

(1) Revetment

Revetments are mainly provided to protect riverbanks from erosion and scouring due to water flow and wave wash. The locations to be provided with revetment are as follows:

(a) Along the concave sides of meander bends of channels;
(b) At the downstream and upstream sides of hydraulic structures including bridges;
(c) On the side slopes of the floodway channel; and
(d) At the water colliding fronts of riverbanks which are prone to erosion.

In general, the following types of revetment are applicable for the river improvement works.

Type of Revetment	Standard Slope	Application
(1) Wet Stone Masonry	Vertical to 1 : 2.0	Small rivers/drainage channel
(2) Wet Stone Pitching	1 : 1.0 or gentler	Height of 3 m to 7 m
(3) Wet Stone Pitching with Concrete Frame	1 : 1.0 or gentler	Sections subjected to strong actions
(4) Dry Stone Pitching (Riprap)	1 : 2.0 or gentler	Height of up to 3 m
(5) Precast Concrete Block	1 : 1.0 or gentler	Height of 3 m to 7 m
(6) Sheet-piled Wall	Vertical	Widely used for both large and small waterfront structures
(7) Gabion Cylinder	1 : 10 or gentler	Transitions of channel

Of these revetment types, the wet stone masonry type is employed for Percut River and Medan Floodway from the technical requirements, availability of materials and lower construction cost, as shown in Fig. 4.2.11 to 4.2.13. The technical details are as follows:

(a) A berm with a width of not less than 1.0 m is provided on side slopes longer than 10.0 m.

(b) The revetment is embedded to an adequate depth (0.5 m or more) below the design channel bed.

(c) Drain pipes with filters are provided in the revetment to relieve hydrostatic pressure of the ground behind the revetment.

(d) Log piles are driven to support the vertical weight of revetment on soft ground.

(e) Gabion mattress is placed at the toe portion of revetment for prevention of scouring. The top elevation of foot protection shall conform to the design riverbed. The width of foot protection is more than 3.0 m.

(2) Foot/Riverbed Protection

To protect the toe of side slope from scouring and degradation of the channel bed, foot protection is provided. The top elevation of the foot protection works is placed at the design riverbed height. In case the existing channel bed is lower than the design bed, the footing is placed at the existing channel bed. The width of foot protection is more than 3.0 m.

(3) Sodding

To protect channel and dike slopes from erosion by raindrop and flowing water, sodding is provided on both sides of the dike and the upper portion of the riverbank.

(4) Groin

The left riverbank in the downstream of Percut River is located in the concave side of a large bend which is prone to erosion and scouring by flood flow. Nine (9) groins are to be provided consecutively in front of the riverbank, together with the revetment, to prevent further bank erosion.

(5) Groundsill

The groundsill is to be located 100 m downstream from the Titi Beshi Bridge which exists in the river section suffering degradation. The proposed groundsill should restore the riverbed elevation around the bridge, which has lowered since the weir was built, to the design riverbed and, also, to stabilize the substructures of Titi Beshi Bridge and the revetments.

Since the design riverbed elevation is about 1.5 m above the existing riverbed, the crest elevation of the groundsill follows the design riverbed, resulting in a groundsill with a height of 1.5 m. This groundsill is of concrete gravity type with an apron to safeguard its own body from hydraulic force during flood time.

Diversion Works

The diversion works are the Deli River Weir and the Floodway Weir. These structures and the channel are designed to meet the basic conditions such as hydraulic requirements, structural stability, topographic constraints and economy.

(1) Hydraulic Requirements

The conditions for the hydraulic design of weirs are as follows:

(a) The design water level in the retarding channel shall be set at EL 34.00 m for both the Immediate Plan and the Urgent Plan.

(b) In the Immediate Plan, the discharge of 70 m^3/s out of 300 m^3/s is to be diverted into the floodway through the Floodway Diversion Weir and the remaining discharge of 230 m^3/s into the downstream channel of Deli River.

(c) In the Urgent Plan stage, the diversion discharge for the floodway will be increased to 120 m^3/s out of 320 m^3/s, while the discharge for the Deli River will be decreased to 200 m^3/s. Therefore, both weirs are required to be modified to meet the change of design discharge between the two stages.

(d) In ordinary time, the whole discharge of Deli River shall flow into its downstream without diversion to the Floodway to maintain the current water uses in the downstream area.

(2) Premises on Weir Design

The fixed weir type is justified as suitable for the diversion weirs. In compliance with the above hydraulic requirements, the basic design is prepared based on the following premises:

(a) The length of the Deli River Weir is restricted due to topographic constraint. In designing the weir, therefore, the crest length is fixed, then the height is adjusted to assure the design diversion discharge.

(b) An orifice is provided in the weir body to enable the low water to flow down towards the downstream of Deli River. The orifice is designed on condition that a discharge of 10.6 m^3/s, which corresponds to a 95-day discharge (occurrence probability of 25%), is carried with some vertical clearance in the orifice.

(c) Modification of the weirs, resulting from the change of diversion discharges between the Immediate and Urgent plans, is made by adjusting the crest height of weirs. The method of raising/cutting the weir crest for the Urgent Plan is also changed, as shown in Fig. 4.2.14.

(d) The length of the Floodway Weir is determined based on the channel width of the floodway.

(3) Location of Weirs

(a) Deli River Weir

To avoid the big difference of overflow depth between the two diversion weirs, the Deli River Weir is placed at UD12, which is the entrance portion to the narrow downstream from the retarding channel.

(b) Floodway Weir

The Floodway Weir is located at the entrance portion to the floodway, which is about 40 m away from the existing low water channel of Deli River.

(4) Type of Weir

There are three types of fixed weir applicable to the site, as follows:

(a) Gravity Type, trapezoid-shaped, ogee and sharp-crested

(b) Armored Dike, trapezoid-shaped and broad-crested

(c) Concrete Step Type (semi-concrete gravity)

Of these weirs, gravity type trapezoid-shaped weir and armored earth dike type were compared, as presented in Table 4.2.3. As a result, the gravity type trapezoid-shaped weir is proposed as the most suitable type for the following reasons:

(a) The maximum water heads are 9.8 m for the Deli River Weir and 7.5 m for the Floodway Weir. These water heads can induce enormous hydrostatic force and uplift pressure. To resist these forces and to keep the structural stability, the weir body should be of a rigid structure with a heavy weight. In this context, the gravity type is preferred for these two weirs.

(b) The gravity type trapezoid-shaped weir is more economical than the armored earth dike type in terms of construction cost.

(c) To obtain a precise and safe diversion of flood flow with a big overflow depth, the trapezoid-shaped fixed weir is preferred, since this type of weir has already been applied in many projects in Indonesia and in Japan.

(d) Deli River Weir is provided with orifices in the weir body. These openings can cause the decrease of weir stability and safety. To ensure the weir's stability and safety, the gravity type is employed.

(e) The gravity type without crest nappe is easy to be modified at the portion of the weir crest for the modification from the Immediate Plan to the Urgent Plan.

<u>Bandar Sidoras Intake Weir</u>

(1) Existing Condition

(a) Weir

The existing weir is a solid overflow structure crossing the river and providing intake with minimum water level for irrigation. The weir comprises a main diversion weir, two intake gates and scouring sluices at both sides of the weir, and a maintenance bridge. The main diversion structure is a concrete-made ogee weir, 28.0 m long (14.0 m × 2) and about 5.8 m high with a nappe-shaped crest. The irrigation water is diverted from the river at the intake gates and runs through box culverts to the irrigation channels on both sides of the river. The size of the box culverts is 2.0 m by 2.0 m in inside cross section. At the end of the box culvert, a control gate is provided as well.

(b) Function and Operation of Weir

Under the normal flow condition, the weir is designed to maintain the water level at about 30 cm above the weir crest. Under this water level, the water depth inside the intake box culvert is kept at 1.3 m. If the inflow to the weir increases, the scouring sluices are to be opened to release the excess water into the downstream so that the water level at the weir could be lowered to the regulated level for irrigation. Other than this operation, the scouring sluices are periodically opened to flush out the sediments which had settled in front of the intake gates.

(c) Features of Irrigation Channel

The Bandar Sidoras Intake Weir currently covers a total irrigation area of 3,457 ha, and the area will be expanded to 3,773 ha in the future. The required water for irrigation is 3.45 m^3/s at the intake points of both right and left sides. This volume will be increased to 3.77 m^3/s in the future. The irrigation channels are lined and trapezoid-shaped channels.

(2) Reconstruction Plan

The existing Bandar Sidoras Intake Weir forms an obstruction during flood time and causes substantial inundation upstream. This weir, therefore, need to be reconstructed in line with the river improvement plan.

The new weir is required to have a sufficient flow capacity for the design flood discharge and to maintain the existing function as an irrigation facility. To fulfill these requirements, the construction of a movable weir or a fixed weir with large capacity sluice gates is conceivable. Judging from the design flood discharge of 320 m^3/s, a movable type of weir is essential.

Three types of gates are generally employed for a river weir which has the purpose of controlling upstream water level for irrigation; namely, Inflatable Rubber Gate, Steel Roller Gate, and Steel Tilting Gate. To select the suitable type of gate, a comparative study focusing on operation, maintenance and construction cost was made (refer to Table 4.2.4). The Inflatable Rubber Gate is proposed in view of the following reasons: (1) construction and maintenance costs are low; (2) operating devices are simple and easy to handle and further, automatic operation for gate deflation is performed without any external power source; (3) only a short time is required for mere periodical maintenance work; and (4) construction and operation have already been experienced successfully in Indonesia in recent years.

(a) Type and Location

An inflatable rubber-made dam is employed for the intake weir. The weir is constructed on the flood channel 150 m upstream of the existing weir, since the weir could be constructed under dry condition and the excavation of low water channel should bring a smooth alignment around the weir site. The existing irrigation channels are extended to the upstream to connect with the proposed box culvert as well.

(b) Hydraulic Design of Intake Weir

The new intake weir is designed to meet the future irrigation plan. The hydraulic requirements are: (1) to divert the irrigation requirement under the river discharge of 4.32 m^3/s corresponding to a flow of 95% occurrence probability a year, and (2) to maintain the water level of the irrigation channel by controlling the volume of intake water with control gates at the inlet of box culvert, employing an orifice type of intake structure.

(i) Water Level at Control Gates

The boundary conditions for the non-uniform flow calculation and results are as tabulated below.

Item	Left	Right
Boundary Condition		
- Discharge	1.68 m^3/s	2.09 m^3/s
- Initial Water Level	EL 3.40 m	EL 3.80 m
- Coefficient of Roughness		
Existing Channel	0.030	0.030
Connecting Channel	0.025	0.025
Box Culvert	0.015	0.015
Results of Calculation		
- Outlet of Box Culvert Water Level	EL 3.65 m	EL 4.04 m
- Inlet of Box Culvert Water Level	EL 3.70 m	EL 4.08 m

Since the water level at the right gate is higher than the left one, the hydraulic calculation to determine water stages of weir and intake facilities was carried out by using the right side condition.

(ii) Crest Elevation of Weir

The crest elevation of weir is set at EL 4.060 m as derived from the water level of the right control gate plus the orifice loss minus the overflow depth of weir.

(iii) Auto-Deflation Water Level (Maximum Overflow Water Level)

To be free from vibration and to avoid deformation of the dam body caused by overflow water, the overflow water depth of the inflatable rubber-made dam is limited to about 20% of the dam height. The inflatable rubber-made dam is designed to deflate automatically depending on the upstream water level.

On the other hand, to prevent sedimentation upstream of the dam, the weir is required to deflate at a certain lapse of time. It should be noted that the existing scouring sluice gates have been opened once a month to flush out sediment. Therefore, to maintain the equipment of inflatable rubber-made dam, gate operation will be conducted twice a year as maintenance operation. The occurrence of auto-deflation shall concentrate in the rainy season from November to December.

From the above, the maximum overflow water depth is designed according to the structural requirement, i.e., the ratio of water depth to dam height is less than 1.4 and the frequency of auto-deflation is about 10 times a year.

River discharge, overflow discharge, water levels and the frequency of auto-deflation are shown in the table below. The auto-deflation water level corresponding to the maximum overflow water depth is set at EL 4.87 m.

River Discharge (m^3/s)	Overflow Discharge (m^3/s)	Upstream Water Level (EL m)	Frequency of Auto-Deflation (times/year)	Ratio of Water Depth to Dam Height
20	16.23	4.63	28	1.182
25	21.23	4.72	20	1.210
30	26.23	4.80	15	1.236
35	31.23	4.87	10	1.258
40	36.23	4.93	7	1.277

(iv) Bottom Elevation of Orifice

To assure the orifice flow at the control gate, the upstream water depth shall be more than 1.8 times the orifice height. The design bottom elevation is set at EL 2.900 m.

Bridge Protection Works

There exist 17 bridges across Percut River as described in the succeeding Subsection 4.2.3. Among them, the Tollway Bridge and the Titi Runtuh Bridge are relatively new. They have a longer bridge length than the design channel width and enough freeboard between the bottom of bridge girder and the design high water level. Further, their piers and abutments are embedded deeply into the subsurface ground. Therefore, these two bridges need not be reconstructed. Instead, the riverbed and side slope around the piers and abutments are to be protected from potential scouring and channel degradation.

As for the existing railway bridge of the Medan-Tembung Line, the bridge girder is more than 2.0 m higher than the design high water level, but the bridge length is shorter than the design channel width by about 7.0 m. In consideration of the difficulty of reconstruction of this bridge, however, it should be left intact but the channel shall be enlarged by adopting a steep side slope. The channel cross-section should pass the design discharge safely with a riverbed width of 14.50 m and a side slope of 1 : 0.6 (vertical to horizontal). Based on this, protection works are carried out by providing revetment for the side slope and channel bed protection.

The National Railway Bridge which has a width of 28 m and a length of 30.2 m is located on the national highway, Medan-Tebing Tinggi. The clearance of the bridge girder from the high water level is about 1.5 m, but the bridge length is shorter than the required river width of 35.33 m. Since extending the bridge is not economically justified and the existing bridge does not bring much inconvenience to the traffic on the main road, the bridge piers and abutments are kept intact, but some riverbed and slope protection works are employed.

A high flow velocity of 3.5 m/s is estimated as the design discharge pass through the section of the bridge, which may bring heavy scouring at and around the piers and abutments. Therefore, protection works are required with concrete wall for the riverbank and concrete blocks for the riverbed. In designing the concrete wall, an appropriate distance from the existing piles shall be kept to avoid any structural impact to the existing structures. Revetments of wet stone masonry are also provided with adequate distance for both up and downstream riverbanks.

Drainage Outlet

River improvement works such as channel excavation, widening and diking usually affect the drainage system around the river channel and it is anticipated that the excavation and channel widening will slightly affect the outlet structures, while diking will change the drainage condition in the adjacent area. Besides, the capacity of the existing drainage outlet is not adequate for the standard of drainage improvement as carried out for Deli River and its tributaries under MUDP II.

Therefore, the drainage improvement will focus on the outlet portion, i.e., the sluice connecting to Percut River and Medan Floodway. Since the inspection roads will be constructed in succession along the riverbanks, the sluice is required to be modified to either a box culvert or a pipe culvert embedded in the riverbank.

In accordance with the topographic condition of the drainage area, the type and method of sluice are proposed as follows:

(1) Gravity flow is principally employed to avoid the big O&M cost to be brought by a pumping station.

(2) Where the design high water level is higher than the ground elevation of the drainage area, a control gate is employed for the sluice to stop the reverse flow from the river/floodway. No gate is provided for the sluice where the design high water level is lower than the ground elevation.

(3) Sluices to be placed close to each other are combined to a certain size of box/pipe culvert to reduce the number of structures in the riverbank.

(4) In case the landside area is low in ground elevation, side ditches are provided along the proposed dike/inspection road to drain inland water.

(5) Either type of sluice, box culvert or pipe, could be classified according to the drainage discharge having a flow velocity of 2.5 m^3/s to 3.0 m^3/s, as below:

Type	Dia./Width (m)	Height (m)	Quantity	Flow Area (m^2)	Design Discharge (m^3/s)
Pipe Culvert	0.600	-	1	0.283	0.707 - 0.989
	0.800	-	1	0.502	0.989 - 1.748
	1.000	-	1	0.785	1.758 - 2.748
	0.800	-	2	1.005	2.748 - 3.517
	1.000	-	2	1.570	3.517 - 5.495
Box Culvert	1.500	1.500	1	2.250	5.495 - 7.875
	2.000	1.500	1	3.000	7.875 - 10.500
	2.000	2.000	1	4.000	10.500 - 14.000
	2.000	2.000	2	8.000	14.000 - 28.000

Through the basic design conditions, the structural dimensions of all the 42 sluices are estimated, as shown in Table 4.2.5.

Waterfront Facilities

The Deli and Percut rivers are featured as urban rivers which serve not only the flood control purpose in flood events but also the purpose of water supply for irrigation, fishponds, and factories located along them. Besides these purposes, the rivers serve for daily water use of local residents living in the adjacent areas. As other similar projects in this country indicate, river improvements have produced good effects in promoting or developing the environmental functions such as the realization of hygienic living environment, the improvement of river water quality, and the creation of better scenic view and pleasant open space.

Taking the above situations into consideration, structures or facilities which can contribute to the realization of the said functions are provided and designed appropriately as much as possible in the planning of river improvement. As proposed, waterfront facilities are provided in the following areas:

(1) Retarding Channel of Upper Deli River (Zone C, Waterfront Zone)

The retarding channel in the Upper Deli River which is located upstream of the proposed diversion weir, is utilized for waterfront activities, sports and/or other recreational purposes during non-flooding period.

According to the hydrological study, the frequency of low water runoff discharges in the Upper Deli River and its corresponding water levels were estimated, as follows:

Return Period (year)	Discharge (m^3/s)	Water Level (EL m)
1	134	32.52
2	120	32.29
5	98	31.86
10	78	31.11

(Note) At Station UD14.000.

To determine the elevation of the retarding area of the channel, the following criteria were adopted:

Zoning	Inundation Occurrence	Area (ha)	Utilization Plan
Zone A	1 time/year	1.84	Park Area & Sports
Zone B	10 times/year	2.71	Free Open Park Space
Zone C	Frequent	0.90	Waterfront / Walking

Land use zoning based on the above criteria and schematic illustration of cross section are as shown in Figs. 4.2.15 and 4.2.16. Besides the above, Zone D is considered as a residential area since this area is located in a relatively low elevation and the newly excavated materials from the proposed floodway would be available for the landfill works.

(2) Meandering Portions of Percut River

The high water channel of Percut River is considered usable as a park, pedestrian path, sports field and other activities. The newly created area by expanding the wide water channel at the meandering stretch will be utilized as free/open park space. The area is not itemized for specific utilization by providing grass/lawn on the ground and pedestrian path along the channel, as well as access road, when required.

Treatment of Batuan River

Batuan River which is a small tributary of Deli River crosses the proposed floodway and its location is shown in Fig. 4.2.17. The catchment area of Batuan River, which is included in the Deli river basin, is small. Therefore, the runoff dishcarge is faster than that of the Upper Deli River, resulting in no additional discharge to the floodway.

The improvement of Batuan River is proposed only for the approach portion to the floodway, to attain the smooth confluence, with the design discharge of 16 m^3/s corresponding to a 10-year return period flood.

4.2.3 Bridges

There are 17 bridges to be affected by the implementation of the Project; namely, 16 bridges along Percut River and one bridge upstream of the proposed Deli River Weir on the Upper Deli River. Of the 17 bridges, 11 are road bridges, one is a railway bridge, three are pedestrian bridges and two are water pipe bridges. Through the evaluation on whether or not the dimensions and structures of the existing bridges would meet the requirements of the proposed river improvement plan, reconstruction, new construction or modification works are proposed, as presented in Fig. 4.2.18.

Condition of Existing Bridges

For the proposed Project, the following three (3) factors were examined to determine whether or not the present conditions of the existing bridges for road, railway, pedestrian and water pipeline meet the requirements of the river improvement plan and construction of the floodway:

(1) Vertical clearance between the high water level and the lowest part of the superstructure with enough reservation for flood flow;

(2) Length of existing bridge sufficient for the proposed widening of river channel; and

(3) Foundation to withstand the riverbed excavation required for the river improvement.

The conditions of the existing bridges were evaluated, as shown in Table 4.2.6. As a result, eight road bridges, two pedestrian bridges and one water pipeline are to be reconstructed. Further, one pedestrian bridge and three water pipeline bridges are to be removed and water pipes are installed on the sidewalk of the new bridge. Moreover, five road, one railway, one pedestrian and three water pipeline bridges are to be newly constructed along the proposed floodway. In addition, foundation protection works are necessary for the Tollway Bridge, the Titi Runtuh Bridge, the Railway Bridge and the National Road Bridge.

Basic Design

For the existing bridges requiring reconstruction, modification and protection works and the 11 new bridges to be constructed across the proposed floodway, aside from the water pipe bridges of truss type design, a basic design is prepared with type selection of superstructure, substructure and foundation, as discussed below.

(1) Superstructure

(a) Span and Type of Superstructure

There are many types of superstructures that are applicable for the proposed bridge sites and conditions. The type that is most suitable for the condition of bridge site was selected, considering the individual characteristics. In general, the relation between type and span of bridge is as shown in the table below. The cross section of each structural type is as shown in Fig. 4.2.19.

Type	Structure	Span (m)	Girder Depth/Span
Metal	Steel Concrete Composite	6 - 30	1/18 - 1/20
	Rolled Beams	10	1/20 - 1/25
	Plate Girders	10 - 40	1/20 - 1/25
	Warren Trusses	30 - 50	-
	Pratt Trusses	50 - 80	-
	K-type Trusses	over 80	-
Prestressed Concrete	Voided Slab	6 - 20	-
	Single T-Beam	12 - 36	-
	Double T-Beam	15 - 24	-
	I-Girder	15 - 35	1/15 - 1/20
	Channel Slab	15 - 30	-
	Box Girder	20 - 31	-
Reinforced Concrete	Slab	6	1/20
	T-Beam	25	1/10 - 1/15

(b) Clearance

The required vertical clearance of bridge and occupancy ratio of river flow area by the pier installation are as follows, in accordance with the river improvement plan:

Vertical Clearance	1.0 m between the design high water level and the bottom of bridge girder.
Occupancy Ratio	Less than 5% of occupancy ratio of flow area of the river channel by the pier installation.

(c) Width of Roadway

The width of roadway depends on the intensity and volume of the existing and future traffic conditions of bridges. The width of roadway is expressed in terms of traffic lane, meaning the width required to accommodate one lane of vehicles. The minimum width of roadway is 6.0 m in accordance with the standards of the Directorate General of Highways, Ministry of Public Works, Government of Indonesia.

In case the width of roadway is more than two lanes, it is desirable to provide a central verge of at least 1.0 m in width to separate the two opposing lanes. The number of lanes in accordance with the road class is as follows:

Kind of Road	Number of Lanes
National Road	2
Provincial Road	1
Kabupaten Road	1
PTP Road	1

(d) Cost of Materials

The costs of materials of the superstructure were compared among the representative types, as shown below.

Material	Type	Span (m)	Width (m)	Cost (Mill. Rp)
Steel	Rolled Beams	31.00	7.00	334.6
	Warren Trusses	31.00	7.00	296.5
Prestressed Concrete	I-Beam	31.00	7.00	313.1
Reinforced Concrete*	T-Beam	31.00	7.00	188.4

(Note) * Including piers

(e) Ease of Construction

Since experience in the construction of the three types of girders/superstructures, namely steel, prestressed concrete and reinforced concrete has been satisfactory in and around the project area, no difficulty in construction may be encountered. However, steel and precast types of prestressed concrete girders are in principle easier for river diversion than the reinforced concrete girder, because temporary works are smaller with the steel and precast type prestressed concrete girders than the reinforced concrete girder.

(f) Maintenance

Less maintenance work is expected for prestressed concrete and reinforced concrete types compared to the steel type. The steel type bridge requires periodical painting work to prevent rusting.

A comparison of bridge types was made among the three, i.e., steel, prestressed concrete and reinforced concrete, as to requirement, ease of construction, construction cost and maintenance, as shown below. The prestressed concrete type of superstructure is correspondingly proposed for the reconstruction and new construction of road and railway bridges.

Item	Steel	Prestressed Concrete	Reinforced Concrete
Requirement of River	Easy to satisfy	Easy to satisfy	Difficult to satisfy
Ease of Construction	Easy for river bridge	Easy for river bridge	Affect river flow
Material Cost	High	Moderate	Low
Maintenance	Periodical painting	Easy	Easy

(2) Substructure

(a) Abutment

An abutment is a structure which supports one terminus of the superstructure of a bridge and, at the same time, laterally supports the embankment which serves as an approach to the bridge. For a river bridge, the abutment also protects the embankment from scouring by river flow. Bridge abutment can be made of masonry, plain concrete and reinforced concrete.

An abutment generally consists of the following three distinct structural elements:

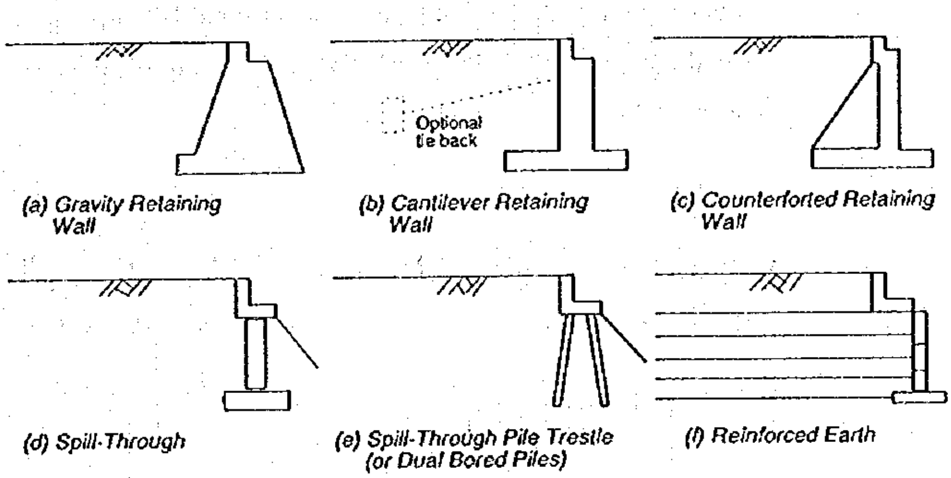
(i) Breast wall, which directly supports the dead load and live load of the superstructure and retains the filling of the embankment in its rear.

(ii) Wing wall, which acts as extension of the breast wall in retaining the fill though not taking any load from superstructure.

(iii) Back wall, which is a small retaining wall just behind the bridge seat preventing the flow of material from the fill onto the bridge seat.

The design of abutment consists in assuming preliminary dimensions depending on the type of superstructure and foundation and checking the stresses at the sill level. The wing wall is cantilevered without extending the base of breast wall for support to accommodate wet masonry abutment. The slope of the bottom edge of the wing is to have this edge below the level of the revetment.

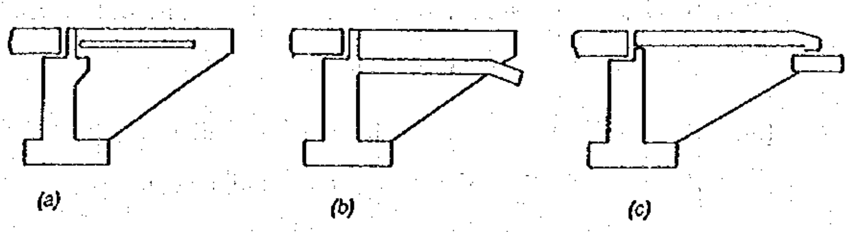
Typical forms of reinforced concrete abutment are as shown below:



In accordance with the proposed cross section of the river improvement plan, Abutment Type *(e)* is selected for the bridges in this Project, because the abutment shall be embedded in the riverside slope provided with wet masonry revetments.

(b) Approach Slab

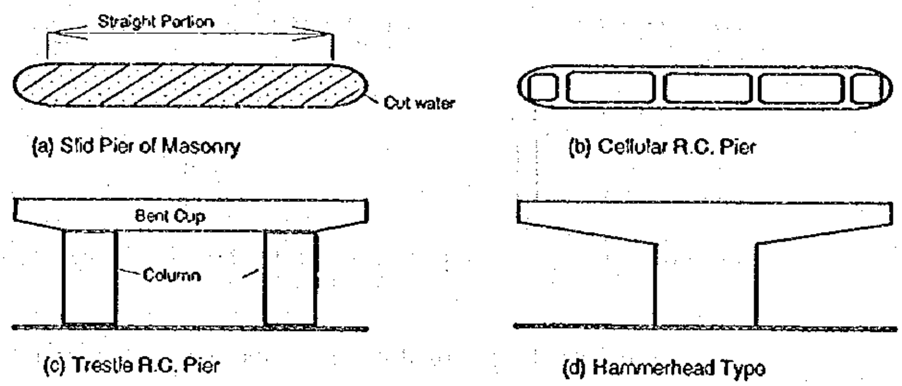
The live load surcharge can be neglected in the design of an abutment when an adequately reinforced concrete approach slab is provided. One end of the approach slab is to rest on the back wall of the abutment. Three (3) types of approach slabs are as shown below:



Approach Slab Type *(a)* is selected, because this type could be free from the abutment, the load of road pavement over the abutment could be reduced and replacement of approach slab could be easier after deterioration.

(c) Pier

The general shape and features of a pier depend to a large extent on the type, size and dimensions of the superstructures and also on the environmental conditions where the pier is located. Pier can be solid, cellular, trestle or hammerhead types, as shown below:



Solid and cellular piers are provided for river bridges to smoothen streamflow and to reduce scouring. Cellular, trestle and hammerhead types use reinforced concrete and the trestle type consists of columns (usually circular) with a bent cap at the top.

The Hammerhead Type (d) is selected because of less restriction to the river channel.

(3) Foundation

The design of foundation is an important part of the overall design for a bridge and affects the aesthetic, safety and economy of the bridge to a considerable extent. To design the bridge foundation, the following factors shall be accurately estimated:

(a) Maximum possible scouring depth;

(b) Minimum grip length required;

(c) Soil pressures at the base; and

(d) Stresses in the structure constituting the foundation.

Foundation applicable for bridges are broadly classified into shallow foundation and deep foundation. A deep foundation is defined as one whose length is greater than its width and which cannot be prepared by open excavation.

Deep foundation is further classified into pile foundation and caisson foundation. A pile foundation is defined as a column support type which may be precast or formed at site. On the other hand, a caisson foundation is a member with a hollow portion, which after installation in place by any means is filled with concrete or other material.

Caisson foundation can be classified into open caisson and pneumatic caisson. An open caisson is one that has no top or bottom cover during its sinking and is more popularly known as well foundation. A pneumatic caisson is a caisson with a permanent or temporary roof near the bottom so arranged that laborers can work in the compressed air trapped under it.

The selection of foundation system of a particular size would depend on the condition of subsoil and the presence of boulders, buried tree trunks, etc. Generally, the pile foundation would be suitable when a thick stratum of soft soil overlays a hard soil.

Pile foundation may be divided into two groups: (1) foundation with friction piles, and (2) foundation with point bearing piles. Friction piles are driven into ground whose strength does not increase appreciably with depth, and a point bearing pile transfers practically all its load by end bearing to the hard stratum on which it rests.

(4) Approach Road

Due to the reconstruction of existing bridges and construction of new ones, approach roads are provided. The horizontal alignment includes a straight path, horizontal deviations and curves. Change in gradient and vertical curves are discussed under vertical alignment of road.

(a) Horizontal Alignment

Change in direction of road alignment is necessary due to obligatory points and the following design factors for horizontal alignment:

(i) Design speed;

(ii) Radius of circular curve;

(iii) Type and length of transition curves; and

(iv) Super-elevation and widening of pavement on curve.

For geometric design, there are three types of curves for horizontal alignment: (1) circular curve, (2) spiral-circle-spiral curve, and (3) spiral-spiral curve. Shape of curve on big radius and small tangent angle of section interpoint shall be in accordance with the table below.

Design Speed (km/hour)		Min. Curve Radius
120	≥	2,000
100	≥	1,500
80	≥	1,000
60	≥	700
50	≥	440
40	≥	300
30	≥	180

Source: Standard Specifications for Geometric Design of Rural Highways

For curves with radius less than the above, spiral-curve-spiral is applied. For curve length of less than 20 m, the shape is spiral-spiral.

(b) Vertical Alignment

To attain a smooth vehicle movement on the road, the change in grade should be smoothened out by vertical curve. The vertical alignment is the elevation or profile of the centerline of the road and it consists of grade and vertical curve. The vertical alignment influences vehicle speed, acceleration, deceleration, stopping distance and comfort in vehicle movement at high speeds.

Based on the evaluation on types and dimensions of superstructure, substructure and foundation of bridges, a preliminary design is prepared for the bridges subject to reconstruction and new construction, as presented in Table 4.2.7.

Railway Bridge

A new bridge is required for the railway, Medan-Deli Tua Line, which will be cut by the proposed floodway. Two types of bridges are compared in terms of construction method, cost and operation/maintenance, namely prestressed concrete single I-Girder and warren truss steel, since the former is selected for all road and pedestrian bridges in the Project and the latter has been oftenly applied for the railway in North Sumatra Province.

The comparative study, as presented in Table 4.2.8, shows that the prestressed concrete single I-Girder bridge is superior to warren truss steel bridge. The construction cost of the former is only 65% of that of the latter because the steel members of the truss structure shall be imported. Maintenance works such as painting of steel members are also indispensable for a long and good operation.

4.3 Project Evaluation

4.3.1 Conditions for the Evaluation

Project evaluation is mainly carried out from the economic point of view, taking social and environmental conditions into account. The economic evaluation at this stage is made, based on the B-P Study, by using present prices and number for equipment and materials in the project cost and for assets to be damaged by flood.

The economic evaluation is conducted by the Economic Internal Rate of Return (EIRR), using present values of economic cost and benefit of the project under the following conditions and assumptions:

(1) Transfer payments such as value added tax (equivalent to 10% of market prices) are not included in the economic cost and benefit;

(2) Standard conversion rate of 97.5% is applied to equipment and materials procured locally, based on export and import statistics in recent years in Indonesia;

(3) Shadow wages of unskilled laborers are taken as 97% of their market prices, taking their employment opportunity into consideration;

(4) Opportunity cost of land to be acquired for the project is assumed to be 80% based on the existing land use in the objective area; and

(5) Economic cost and benefit do not take inflation into account.

Economic life of the project (hereinafter referred to as "project life") is taken as 50 years after completion of the construction works, and the benefit and O&M cost of the project are assumed to occur every year during the project life.

4.3.2 Economic Cost

The Project's financial and economic costs are compared, as shown below:

Financial Cost		Economic Cost	
Project Cost	Annual O&M Cost	Project Cost	Annual O&M Cost
188,716	1,471	165,475	1,297

In the table above, the annual O&M cost is assumed to be 1% of the direct construction cost, and partial annual O&M cost, which is required under the construction, is assumed to be proportional to the progress of construction works.

4.3.3 Economic Benefit

The economic benefit is classified into three: (1) direct effect of reduction in flood damage to assets, (2) reduction effect of flood damage to economic activities and public facilities, and (3) other socio-economic effects. Firstly, a flood damage analysis is made to assets, which are composed of general assets (buildings and household effects) and agricultural field crops. Next, flood damage to public facilities and economic activities is estimated as a function of the flood damage to general assets. Finally, socio-economic effects of recreation facilities in the retarding area are discussed.

Flood Damage Analysis

Flood damage to general assets is estimated by using (1) the number of assets to be inundated by flood, (2) the appraised value of assets, and (3) the damage rate of inundated assets. On the other hand, the damage to agricultural field crops is estimated by using (1) the area of inundated agricultural crop fields, (2) the production per unit area, and (3) the damage rate of inundated agricultural field crops.

(1) Number and Area of Assets in Flood Prone Area

The major assets in flood-prone areas include residential houses, shops, public/private buildings (office, school, hospital, mosque/church, etc.) and agricultural crops (paddy, upland crops and plantation crops).

The number and area of assets to be damaged by floods are based on the data of the B-P Study (Table 4.3.1) which were collected by mesh-map as shown in Fig. 4.3.1. These data were counted and measured on aerial photographs and topographical maps made in 1991. In the present D/D Study, the number of buildings in the flood prone area is taken to increase in proportion to the increase in number of households in Medan City and its surrounding areas. Its annual increase rate is assumed to be 3.8% for the period 1990-2000 and 3.5% after the year 2000, during the period of project life. The percentage above is based on the intercensal rate, the household projection of MMUDP and the population projection of the B-P Study. However, the increase rate of damage is assumed to be 3.5% and 3.0% for the respective periods, because the ratio of flood damage to general assets and agricultural crops is approximately estimated at 95 : 5, in accordance with the B-P Study.

According to the statistics on agricultural food crops and plantation estate crops in the Study Area, these harvest and productive areas have increased year by year. However, the damage to agricultural field crops is approximately estimated to be only 5% of the total flood damage as mentioned above. On the other hand, in recent years, several settlements have been constructed in open space and/or agricultural fields and it is expected that the construction of settlements will continue for the time being in accordance with the progress of urbanization in Medan City. Judging from these facts, the increase in agricultural field area during the period of project life is taken into account in the present study.

(2) Appraised Value of Assets

An interview survey was carried out to obtain the new appraised value of buildings and household effects for general households, shops and schools in the flood prone area of the Deli and Percut river basins. Based on 100 samples of households which were obtained at random by the interview survey, the average appraised value per building was estimated at Rp. 10.3 million for residences, Rp. 19.8 million for shops and Rp. 156 million for schools. The total value of goods per household was estimated at Rp. 5.7 million for residences, Rp. 15.1 million for shops and Rp. 19.4 million for schools. The increase rate of appraised value of school assets for the period from 1991 (Base year of the B-P Study) to 1995 was applied to the appraisal of other assets such as offices, hospitals, and mosques/churches.

With regard to agricultural field crops, production (tons/ha) and prices (Rp. million/ton) in 1995 were estimated on the basis of agricultural statistics and producer price indices in North Sumatra Province, Deli Serdang District and Medan City. The results, together with the appraisal of general assets, are listed in Table 4.3.2.

(3) Flood Damage Rate of Assets

The flood damage to buildings, household effects and agricultural crops can be estimated by applying the respective damage rates used in the B-P Study. These damage rates are summarized in Table 4.3.3.

In addition to the direct flood damage to assets, some economic losses, which are due to the suspension of business activities and road traffic in and around the flooded area, were considered. According to the Flood Control Manual of the Ministry of Construction of Japan, the economic loss in business suspension (including traffic suspension) is approximately 6% of the flood damage to general assets. Therefore, the economic loss in business suspension (including the road traffic suspension) caused by flood is taken as 6% of the total damage to general assets.

(4) Summary of Flood Damage

Under the conditions above, the damage amount is estimated by asset for each flood probability, and the results are given in Table 4.3.4. The total damage amounts are as summarized below:

Unit: Rp. Million

Return Period (Year)	Deli River	Percut River	Total
2	87,739	-	87,739
5	120,123	18,989	139,112
12	123,856	20,995	144,851
25	144,442	27,893	172,335
40	153,794	28,749	182,543
70	163,969	29,536	193,505
110	170,320	32,388	202,708

(5) Average Annual Flood Damage

Average annual flood damage is estimated by using the total flood damage above, taking the occurrence probability of flood into account. The results are summarized as follows:

Unit: Rp. Million

Return Period (Year)	Deli River	Percut River	Total
5	-	7,596	7,595
12	-	9,928	9,928
25	5,813	10,987	16,800
40	8,050	11,412	19,462
70	9,752	11,724	21,476
110	10,620	11,885	22,505

In the table above, the average annual flood damage until a 12-year return period flood for Deli River is regarded as zero, because flood protection works corresponding to the said return period are being executed at present. Taking this matter into account, the average annual flood damage which corresponds to the Immediate and Urgent plans (25-year and 40-year return periods) is estimated at Rp. 16,800 million and Rp. 19,462 million, respectively.

Average Annual Benefit

After completion of the construction works for the Immediate and Urgent projects, the average annual flood damage corresponding to the respective projects is expected to be eliminated, i.e., it would be given as an average annual benefit of the projects.

The partial annual benefit expected to accrue before completion of the construction works is assumed to be proportional to the progress of construction works by the same means as the O&M cost, i.e., the partial benefit would be approximately estimated by a ratio of the invested construction cost to the total construction cost.

Further, based on the foregoing discussion, the average annual benefit is expected to increase at the annual rate of 3.5% for the period 1990-2000, and 3.0% after that year during project life, because of the increased number of general assets year by year. The annual flow of economic benefit, together with the economic cost, is given in Table 4.3.5.

4.3.4 Economic Evaluation

Estimate of EIRR

The economic evaluation for the Immediate and Urgent plans is made by comparing both present values of economic cost and benefit using the annual flows of the cost and benefit given in Table 4.3.5. As a result, EIRR is as summarized below:

Plan	Return Period	EIRR (%)
Immediate Plan	25-Year	14.42
Urgent Plan	40-Year	15.43

The percentage of EIRR above shows that the project is economically justifiable, because the opportunity cost of capital is estimated to be 10 to 12% in Indonesia.

Sensitivity Test

A sensitivity test for the EIRR above is made for the 10% increase in economic cost and the 10% decrease in economic benefit. The results are given as follows:

(Unit: %)

Plan	10% Increase in Cost (1)	10% Decrease in Benefit (1)	Combination of (1) and (2)
Immediate Plan	13.39	13.23	12.30
Urgent Plan	14.30	14.12	13.50

The EIRR figures above indicate that there is no question about the economic viability of the project, even if both conditions, the 10% increase in cost and 10% decrease in benefit, are combined.

Other Impacts - Economic Effect of Recreation Park

(1) Concept of Benefit for Recreation Park

In this study, a recreation park is planned in the retarding channel immediately upstream of the diversion weirs in the Upper Deli River. The retarding area is approximately 5 ha, 1.2 ha (24%) of which is provided as a recreation park with such facilities as flower garden, parking area, tennis court, soccer ground, etc.

The construction cost of this park is estimated at approximately Rp. 290 million, composed of Rp. 151 million (52%) for land preparation and Rp. 139 million (48%) for recreation facilities. In the present plan, only the land preparation work is included in the project cost. Annual O&M cost is assumed to be approximately 1% of the total construction cost.

The park is expected to be utilized as a place for recreation of inhabitants in the surrounding areas. However, it is difficult to accurately evaluate the economic benefit of the park without a fee. Therefore, for estimating the broad benefit, the introduction of the concept of "willingness to pay" and "consumer surplus" as a clue is attempted. That is, the visitors are regarded as having a "willingness to pay" for the time and cost spent to get recreation at the park using their surplus time.

The benefit could be roughly estimated by using (1) the number of visitors, (2) the time spent by them (including time spent for going to and from the park), and (3) the transportation costs. In general, the number of visitors is given as a function of distance from the park and population in the surrounding areas. The spent time is presented in monetary term, under the concept of consumer surplus.

For obtaining similar data for these factors, an interview survey should be carried out at any park with similar conditions in terms of location and facilities. Actually, however, it is difficult to find out such a similar park in and around Medan.

Nevertheless, a broad estimate of the economic benefit to be brought by the park was made to obtain a basic material for formulating the management plan of the river basin and based on some results of interview surveys in other countries, the basic conditions for the economic evaluation of this park were assumed, as below.

(2) Conditions for the Estimation of Benefit

The conditions for the estimation of benefit are given below. Based on these conditions, the average expenditure per capita per household is calculated at Rp. 2,000 per day.

(a) Number of Visitors

The number of visitors is assumed based on land area and facilities of the park, and population in the surrounding areas, as follows:

Weekdays	50 persons per day
Holidays	150 persons per day

(b) Number of Holidays in Indonesia

The number of holidays in Indonesia is 117 days per year which contains Saturdays, Sundays and national holidays.

(c) Hours Spent for Recreation in the Park per Day

The number of hours spent for recreation in the park per day is four hours in the daytime (i.e., half day) including transportation hours to and from the park.

(d) Average Transportation Cost

The average transportation cost is Rp. 1,000 per person-day which means fuel expenses of car and motorcycle or bus charge.

(e) Average Household Expenditure (or Income) per Month

The average household expenditure (or income) per month is Rp. 300,000.

(f) Average Household Size

The average household size is 5 persons.

(3) Estimation of Benefit

Under the conditions above, the annual economic benefit of the park is estimated at Rp. 22.5 million for 15,000 visitors (person-day) in total, based on the concept of "willingness to pay" and "consumer surplus" of the visitors. As a result, the economic benefit of land preparation work is estimated to be Rp. 11.7 million per annum in accordance with the allocation based on both construction costs of land preparation and recreation facilities. This benefit is evaluated as an additional effect of the river improvement works.

(4) Economic Evaluation of the Park

In the present study, the land preparation work for the park is scheduled to commence in 1997 and completed within the year. Taking this schedule and the project life into account, EIRR of land preparation for the park is estimated at approximately 6% based on both present values of cost and benefit mentioned above. Economically, this effect is not too large; however, it would have a significant socio-economic impact on the river improvement project.

TABLES

CHAPTER 4

FORMULATION OF DEFINITIVE PLAN

Table 4.2.1 COMPARISON OF CHANNEL TYPE OF PERCUT RIVER

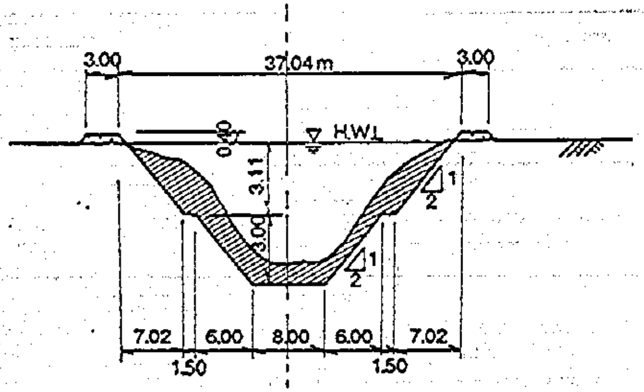
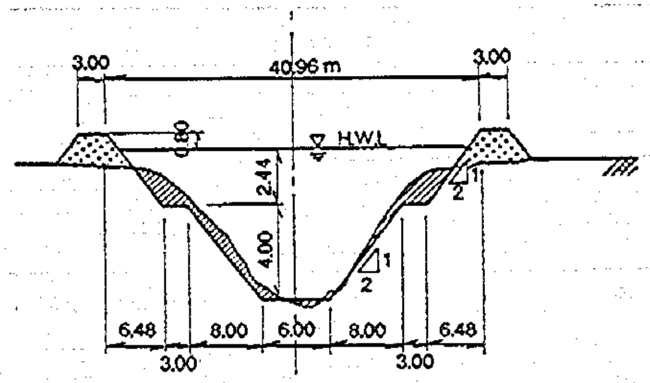
ITEM	ALTERNATIVE - A	ALTERNATIVE - B
Typical Cross Section of River Channel (PE13+244 - PE28)		
Hydraulic Design of River Channel	- H.W.L of the channel is set lower than the ground height. - Inspection roads are provided at both river banks. $Q = \frac{1}{n} \times I^{1/2} \times R^{2/3} \times A$ n = 0.033, I = 1/825, R = 3.47m A = 132.87 m^2 v = 2.42 m/s, Q = 321.12 m^3/s	- H.W.L of the channel is about 0.5m higher than the ground height. - The river dike with a height of about 1.5m is provided at both river banks. $Q = \frac{1}{n} \times I^{1/2} \times R^{2/3} \times A$ n = 0.033, I = 1/825, R = 3.34m A = 136.23 m^2 v = 2.36 m/s, Q = 321.06 m^3/s
Impact on Related Facilities and Structures	- As the flood water level is kept below the ground height, control gates of the drainage channels are not necessary. - Bridge length is shorter than that of Alternative-B.	- Drainage channels will be affected by high flood water of PERCUT river. Consequently, control gates are required at the confluence points. - Bridge length is longer than that of Alternative-A, and the longer approach road is necessary.
Main Construction Works and Cost	(million Rp) (1) Excavation 650,000 m^3 4,453 (2) Embankment 45,000 m^3 235 (3) Revetment 31,000 m^2 1,240 (4) Bridge Reconstruction 7 nos 12,200 (5) Drainage Sluice with Gate 44 pcs 2,640 Sub total 20,768	(million Rp) (1) Excavation 390,000 m^3 2,672 (2) Embankment 340,000 m^3 1,773 (3) Revetment 32,000 m^2 1,280 (4) Bridge Reconstruction 7 nos 13,700 (5) Drainage Sluice without Gate 44 pcs 3,200 Sub-total 22,625
Compensation Works and Cost	(million Rp) (1) Land acquisition 49.5 ha 8,177 (2) House evacuation 170 nos 533 Sub total 8,710	(million Rp) (1) Land acquisition 61.5 ha 10,159 (2) House evacuation 185 nos 580 Sub total 10,739
Total Construction Cost	**Million Rp** 29,478	**Million Rp** 33,364

Table 4.2.2 COMPARISON OF ALTERNATIVES OF FLOODWAY ROUTE

ITEM	ROUTE - A	ROUTE - B	ROUTE - C
Topography and Land Use	- Ground height varies EL +32m to EL+39m, and average elevation is about EL+35m. - Residential area is more than 70 % of the floodway route area.	- Ground height varies EL +32m to EL+41m, and average elevation is about EL+37m. - The area of the route consists of residential area in western part, and paddy field and swampy land in eastern part.	- Ground height varies EL +34m to EL+43m, and average elevation is about EL+38m. - Almost same pattern of land use as the ROUTE-B.
Features of Floodway	- The floodway is about 3,700 m long, and has a width of 35m to 52m. - Height of the open channel is 7.0 to 13.0 m, the smallest of all. This channel is required less excavation.	- The floodway is about 3,800 m long, and has a width of 37m to 56m. - Height of the open channel is 7.0 to 15.0 m. Excavation volume is bigger than that of ROUTE-A.	- The floodway is about 3,600 m long (the shortest of all) and has a width of 40m to 58m. - Height of the open channel is 8.0 to 16.0 m, and this channel needs bigger excavation.
Diversion Structures	- Deli and Floodway weirs are provided at the lowest portion of the retarding channel. This portion is preferred for diversion of flood flow.	(The same weirs as those of ROUTE -A)	- Deli and Floodway weirs are to be constructed at different portions in the retarding channel, and the Floodway weir will be bigger in body length than that of ROUTE-A & B
Major Construction Works	(million Rp) (1) Excavation 974,000 m^3 6,670 (2) Revetment 102,000 m^2 4,080 (3) Bridge 9 nos 16,200 (4) Diversion Weir 4,000 m^3 1,300 (5) Upper Percut River Improvement 0 m 0 Sub total 28,250	(million Rp) (1) Excavation 1,320,000 m^3 9,040 (2) Revetment 137,000 m^2 5,480 (3) Bridge 6 nos 10,800 (4) Diversion Weir 4,000 m^3 1,300 (5) Upper Percut River Improvement 1,100 m 1,050 Sub total 27,670	(million Rp) (1) Excavation 1,280,000 m^3 8,770 (2) Revetment 132,000 m^2 5,280 (3) Bridge 6 nos 10,800 (4) Diversion Weir 8,000 m^3 2,550 (5) Upper Percut River Improvement 2,100 m 2,000 Sub total 29,400
Compensation Works	(1) Land Acquisition 18 ha 11,500 (2) House Evacuation 197 nos 920 Sub total 12,420	(1) Land Acquisition 20 ha 7,950 (2) House Evacuation 118 nos 550 Sub total 8,500	(1) Land Acquisition 19 ha 7,550 (2) House Evacuation 132 nos 610 Sub total 8,160
Total Construction Cost	million Rp 40,670	million Rp 36,170	million Rp 37,560
Evaluation	Inadequate	Adequate	Inadequate

Table 4.2.3 COMPARISON OF DIVERSION WEIR TYPE

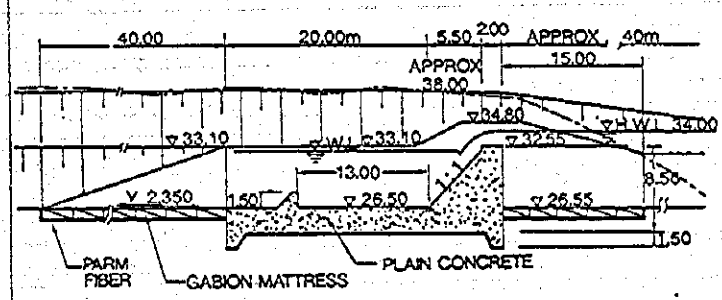
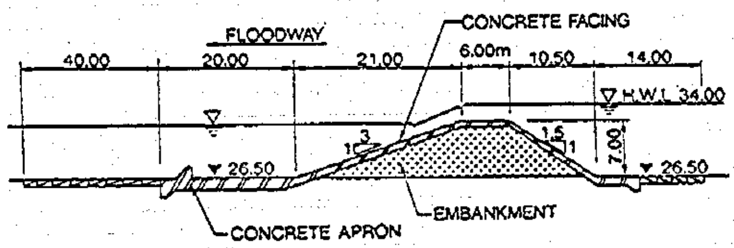
ITEM	CONCRETE GRAVITY TYPE	ARMORED EARTH DIKE TYPE
Typical Cross Section of Weir		
Structural Characteristic	- A rigid and heavy concrete body can resist enormous dynamic water pressure and uplift. - An orifice can be provided in the concrete weir body. - Sub-base layer has sufficient bearing capacity to support the weir body.	- To resist the flowing force over the dike, the dike surface is covered by thick concrete layer with water-tightness. - Since the weir is subjected to tremendous flowing force and seepage pressure, a bigger cross section of dike is to be employed .
Resistance against Uplift Pressure	- The concrete apron should be thick enough to cope with big uplift pressure.	- Concrete cover is designed to be thick enough to resist uplift pressure, and further air holes and water holes are provided in the dike body.
Construction and Maintenance	- Construction of the weir is fairly easy to carry out. - Maintenance works can be minimizes.	- Special care is necessary for the compaction of embankment in order to reduce settlement. When cracks on concrete cover caused by the dike settlement arise, repair should be done immediately.
Modification Work	- Modification of the weir body for the Urgent Plan can be done easily.	- In modifying the weir body for the Urgent Plan, some demolition work and reconstruction of top portion of the weir are required.
Main works and Construction Cost	(unit) (million Rp) (1) Excavation 13,000 m^3 89 (2) Backfill 10,000 m^3 53 (3) Plain Concrete 3,700 m^3 840 (4) Reinforced Concrete 1,600 m^3 583 (5) Rubble Stone Concrete 200 m^3 8 (6) Revetment 800 m^2 32 (7) Riverbed Protection 2,500 m^2 144 Total 1,749	(unit) (million Rp) (1) Excavation 24,000 m^3 165 (2) Embankment 5,500 m^3 29 (3) Plain Concrete 1,800 m^3 441 (4) Reinforced Concrete 2,500 m^3 866 (5) Rubble Stone Concrete 400 m^3 15 (6) Revetment 8,000 m^2 318 (7) Riverbed Protection 4,000 m^2 230 (8) Backfill 4,500 m^3 24 Total 2,088
Evaluation	Adequate	Inadequate

Table 4.2.4 COMPARISON OF GATE TYPE

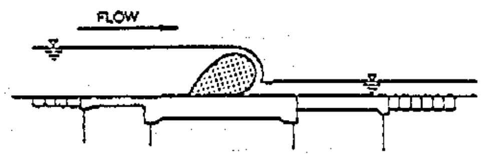
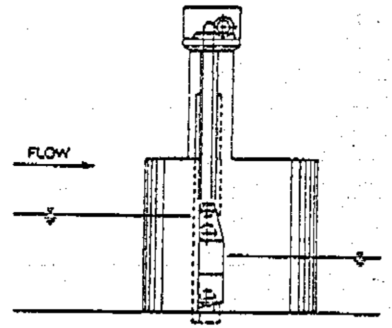
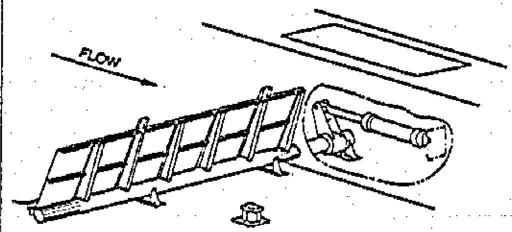
Item	Rubber Gate	Steel Roller Gate	Steel Tilting Gate
General View			
Mechanical & Structural Characteristics	- Gate body is inflated by air or water. - Gate body is made of strong synthetic rubber which has at least 25 years durability. - Mechanical system is simple. - Substructure will be small in structural scale.	- Gate body is lifted vertically by hoisting devices. - Gate is lifted higher than the dike height. - Both superstructure and substructure will be rather big in structural scale.	- Gate body is lifted by hydraulic hoist. - Deck slab must have a drop for the storing space of gate. - Mechanical system is rather complicated - Substructure will be small in scale.
Flood Control Ability	- Since the sediment or boulder stones are few at the weir site, reliability of deflation is high. Therefore, flood control ability is pretty good.	- As the gate body can be lifted up to the safety position during floods, flood control ability is better than others.	(The same as Rubber Gate)
Gate Operation	- Automatic operation for the gate deflation can be performed without any power in flooding events. - It is difficult to control the water level and discharge of the river. - Operating devices are simple and easy to handle.	- Automatic operation for gate lifting can not be performed without power. - It is easy to control the water level and discharge of the river by gate operation.. - Operating facilities are complicated in structure.	- Automatic operation for the gate deflation can be performed without any power in flooding time. - This type has an excellent performance in controlling the water level and discharge of the river. - Operating devices are simple and easy to handle.
Maintenance	- Working life is 25 years or more. - Periodical painting is not necessary. - Inspection of the operating devices can be performed easily because devices are simple. - Repairing is relatively easy.	- Working life is about 40 years. - Periodical (every 7 years) painting is necessary. - Inspection of the operating devices is easy but it should be done frequently.	- Working life is 25 years or more. - Periodical (every 7 years) painting is necessary. - Inspection of the operating devices is not so easy.
Components of Gate Structure	[Gate] Rubber gate.....L=28.0m, H=3.0m x 1 Pipes and Operating system, Operation room Maintenance bridge, [Substructure] Concrete V=1,200 m^3, Sheet pile Steel pipe pile φ600, L=30m, n=80	[Gate] Roller gate........L=14.0m, H=3.0m x 2 Lifting device and Operating system....3 sets [Pier & Operation deck] 3 places, Concrete V=200 m^3 [Substructure] Concrete V=1,300 m^3 Steel pipe pile φ700, L= 30.0m, n= 80	[Gate] Roller gate........L=14.0m, H=3.0m x 2 Lifting device & Operation system, Operation house [Substructure] Concrete V=1,300 m^3, Steel sheet pile Steel pipe pile φ600, L=30m, n=80
Construction Cost (Gate structure only)	4,758 Million Rp	6,358 Million Rp	5,299 Million Rp
Evaluation	- Most economical type - Maintenance cost is less than that of other types. - Eeasy maintenance & operation can be realized. Adequate	- Costwise (both construction and maintenance costs) this tipe is disadvantageous. Inadequate	- This type is more costly than the rubber gate and needs more maintenance cost. Inadequate

Table 4.2.5 PROPOSED DRAINAGE OUTLET ALONG PERCUT RIVER AND FLOODWAY

	Drainage Outlet No.	Location	Type	Gate	Bottom Elevation (EL.m)	Ground Height (EL.m)	Design Riverbed (EL. m)	HWL (EL.m)	Dike Crest (EL.m)	Catchment Area (ha.)	Assumed Discharge (m^3/s)	Note
Right Bank	SR1	PE. 166 + 80	Pipe Culvert D=800mmx2		14.800	17.300	11.145	17.255	18.055	37.890	2.508	
	SR2	PE. 176 + 85	Pipe Culvert D=800mmx2		16.100	18.600	12.365	18.475	19.275	50.960	2.758	Railway Br.
	SR3	PE. 200 + 10	Open Ditch B=600mm		20.000	21.700	15.188	21.298	22.098	0.990	0.093	Denai Br.
	SR4	PE. 200 + 25	Pipe Culvert D=1000mm		20.800	21.800	15.206	21.316	22.116	11.040	0.806	Denai Br.
	SR5	PE. 216 + 0	Open Ditch B=600mm		23.800	24.300	17.052	23.162	23.962	0.840	0.088	
	SR6	PE. 218 + 40	Pipe Culvert D=600mm		23.000	24.700	17.393	23.503	24.303	10.180	0.749	
	SR7	PE. 234 + 20	Pipe Culvert D=800mm		24.000	26.000	19.326	25.436	26.236	15.500	0.970	
	SR8	PE. 246 + 30	Pipe Culvert D=800mm		27.500	27.100	20.794	26.904	27.704	15.010	1.284	Amplas Br.
	SR9	PE. 255 + 20	Pipe Culvert D=600mm		24.300	28.300	21.862	27.972	28.772	6.390	0.583	
	SR10	PE. 259 + 0	Box Culvert 2.0x2.0x2		24.300	28.700	22.310	28.420	29.220	498.490	22.293	*** River
	SR11	PE. 271 + 40	Pipe Culvert D=800mm		28.000	30.400	24.016	30.126	30.926	11.850	1.144	
	SR12	PE. 272 + 85	Pipe Culvert D=1000mm		29.500	30.200	24.186	30.296	31.096	14.500	2.376	
Left Bank	SL1	PE. 85 + 0	Pipe Culvert D=600mm	1 Flap Gate	4.000	5.500	2.066	7.766	8.566	17.740	0.709	Perkebunan Br.+100m
	SL2	PE. 95 + 35	Box Culvert 2.0x1.5x2	2 Slide Gates	5.000	7.040	2.925	8.625	9.425	559.020	14.882	
	SL3	PE. 138 + 55	Box Culvert 1.5x1.5x1	1 Slide Gate	11.000	12.800	7.694	13.804	14.604	109.230	6.074	Payung Br.+110m
	SL4	PE. 155 + 90	Box Culvert 2.0x1.5x1	1 Slide Gate	13.000	15.400	9.855	15.965	16.765	119.250	7.474	Under Construction
	SL5	PE. 176 + 55	Box Culvert 1.5x1.5x1		16.000	18.500	12.329	18.439	19.239	54.000	5.553	Railway Br.
	SL6	PE. 176 + 85	Box Culvert 2.0x1.5x1		16.000	18.600	12.365	18.475	19.275	62.000	8.030	Railway Br.
	SL7	PE. 189 + 40	Pipe Culvert D=800mm		18.000	20.500	13.901	20.011	20.811	9.000	1.258	
	SL8	PE. 198 + 35	Pipe Culvert D=1000mmx2		21.000	21.500	14.956	21.066	21.866	35.200	3.781	
	SL9	PE. 200 + 25	Pipe Culvert D=600mm		21.000	22.000	15.206	21.316	22.116	2.500	0.290	Denai Br.
	SL10	PE. 200 + 40	Pipe Culvert D=600mm		20.500	21.700	15.224	21.334	22.134	7.750	0.573	Denai Br.
	SL11	PE. 206 + 0	Pipe Culvert D=600mm		20.500	22.100	15.862	21.972	22.772	0.360	0.053	Toll-way Br.
	SL12	PE. 206 + 55	Open Ditch B=1000mm		23.000	22.500	15.929	22.039	22.839	23.000	1.716	Toll-way Br.
	SL13	PE. 212 + 0	Box Culvert 1.5x1.5x2		21.000	23.200	16.604	22.714	23.514	181.600	12.564	JL. Lomo
	SL14	PE. 222 + 0	Box Culvert 2.1x2.4x2		21.500	24.400	17.847	23.957	24.757	345.760	23.880	Binjai Br.
	SL15	PE. 222 + 15	Pipe Culvert D=1000mm		21.500	25.100	17.865	23.975	24.775	32.600	2.350	JL. Timur
	SL16	PE. 246 + 40	Box Culvert 2.0x2.0x1		23.500	27.500	20.806	26.916	27.716	108.420	10.906	Amplas Br.
	SL17	PE. 250 + 90	Pipe Culvert D=600mm		26.000	27.500	21.369	27.479	28.279	14.350	0.849	
	SL18	PE. 255 + 15	Pipe Culvert D=800mm		26.500	28.000	21.856	27.966	28.766	20.960	1.736	Pipe Bridge
	SL19	PE. 258 + 25	Pipe Culvert D=600mm		27.500	28.700	22.219	28.329	29.129	10.170	0.748	
	SL20	PE. 259 + 60	Pipe Culvert D=600mm		28.000	29.000	22.383	28.493	29.293	3.780	0.272	
	SL21	PE. 262 + 80	Pipe Culvert D=1000mmx2		26.000	29.803	22.764	28.874	29.674	55.090	3.429	
	SL22	PE. 264 + 90	Pipe Culvert D=600mm		26.896	29.400	22.995	29.105	29.905	4.770	0.405	
	SL23	PE. 269 + 50	Open Ditch B=600mm		30.398	30.000	23.687	29.797	30.597	4.090	0.507	National Road Br.
	SL24	PE. 269 + 80	Open Ditch B=600mm		29.719	33.100	23.723	29.833	30.633	9.230	0.611	National Road Br.
	SL25	PE. 274 + 55	Pipe Culvert D=800mm		32.000	33.000	24.322	30.432	31.232	17.740	0.888	
Floodway	SF1	FW. 6 + 50	Pipe Culvert D=1000mm		32.000	33.477	25.088	30.888	31.688	20.200	0.890	
	SF2	FW. 9 + 81	Box Culvert 2.0x2.0x1		33.000	35.484	25.229	31.029	31.829	150.150	7.003	
	SF3	FW. 13 + 0	Pipe Culvert D=1000mm		35.667	36.167	25.365	31.165	31.965	9.000	0.721	
	SF4	FW. 16 + 0	Pipe Culvert D=1000mm		0.000	35.147	25.493	31.293	32.093	40.500	1.971	
	SF5	FW. 25 + 24	Box Culvert 2.0x2.0x2		32.500	34.035	25.888	31.688	32.488	422.110	16.900	Butuan River
	SF6	FW. 30 + 0	Pipe Culvert D=1000mm		0.000	37.938	26.094	31.894	32.694	9.375	0.477	
	SF7	FW. 38 + 50	Pipe Culvert D=1000mm		34.300	34.800	26.457	32.257	33.057	11.250	1.889	

Table 4.2.6 CONDITION OF EXISTING BRIDGES

a. Percut River

No.	Bridge No.	Name of Bridge	Station (PE.m)	Name of Village	Administration Office	Existing Bridge Length (m)	Width (m)	Material of Superstructure	Condition Super-structure	Sub-structure	Approach Road
1	Br.P1	Titi Besi Br.	057+05	Dusun Mayung	DS	30.00	3.50	Steel girder	Cracked	Bad	Asphalt penetration
2	Br.P2	Perkebunan Br.	084+28	Centis	PTP IX	21.00	3.50	Steel Suspension	Bad	Bad	Gravel metaling
3	Br.P3	Pedestrian Br.	114+76	Bandar Setia	DS	17.50	2.00	Steel girder	Fair	Fair	Earth hardening
4	Br.P4	Titi Runtuh Br.	129+53	Bandar Setia	PTP IX	37.00	4.00	Steel Truss	Good	Fair	Gravel metaling
5	Br.P5	Payung Br.	137+39	Psr XII.L.Dendang	DS	19.50	3.50	Steel girder	Good	Good	Gravel metaling
6	Br.P6	Pedestrian Br.	147+58	Dusun Anggerek	SDM	24.00	1.50	Steel girder	Fair	Fair	Gravel metaling
7	Br.P7	Medan-Tembung Br.	169+59	Tembung	MM	20.50	7.30	Concrete Girder	Cracked	Fair	Asphalt concrete
8	Br.P8	Railway Br.	176+73	Tembung	RWS	32.80	1.15	Steel Truss	Fair	Fair	Earth hardening
9	Br.P9	Medan -Denai Br.	200+25	Denai Ujung	MM	20.50	7.30	Concrete Girder	Fair	Fair	Asphalt concrete
10	Br.P10	Tollway Br..	206+08	- ditto -	Jasa Marga	46.00	35.90	Concrete Girder	Good	Good	Asphalt concrete
11	Br.P11	Binjei Br.	222+00	Menteng Raya	MM	32.40	9.00	Concrete Girder	Fair	Good	Asphalt concrete
12	Br.P12	Pedestrian Br.	224+66	- ditto -	MM	23.00	2.00	Steel Suspension	Broken	Bad	Gravel metaling
13	Br.P13	Amplas Br.	246+58	Amplas	MM	28.60	6.00	Concrete Girder	Fair	Good	Asphalt concrete
14	WBr.P2	Water Bridge (600x2)	255+10	Amplas	PDAM	30.00		Steel Truss	Fair	Good	- non -
15	WBr.P2	Water Brdige (600)	269+60	Amplas	PDAM	30.00		Steel Truss	Fair	Good	- non -
16	Br.P14	National Road Br.	269+75	Amplas	NSMA	30.00	26.00	Concrete Girder	Fair	Good	Asphalt concrete

b. Upper Deli River

No.	Bridge No.	Name of Bridge	Station (FW.m)	Name of Village	Administration Office	Existing Bridge Length (m)	Width (m)	Material of Super structure	Condition Super structure	Sub structure	Approach Road
17	Br.F7	Pedestrian Br.	037+70	Gg. Seksama	MM	33.80	1.20	Steel Girder	Bad	Bad	Earth hardening

Note :

DS	Deli Serdang Public Works
MM	Medan City Public Works
PTP-IX	Plantation
PJKA	North Sumatra Railway Service

SDM	Kelurahan, Dusun anggerek
DPUP	North Sumatra Irrigation Works
NSMA	North Sumatra Province Medan Artery
PDAM	Medan City Water Works Corporation

Table 4.2.7 PROPOSED DIMENSION OF BRIDGE TYPE

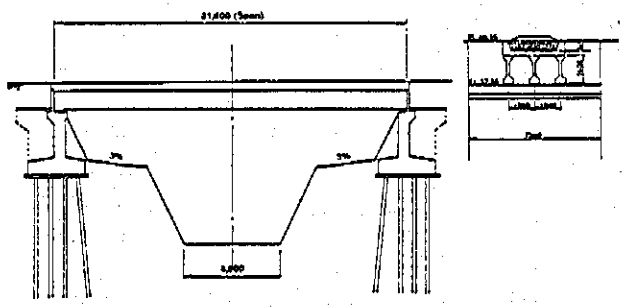
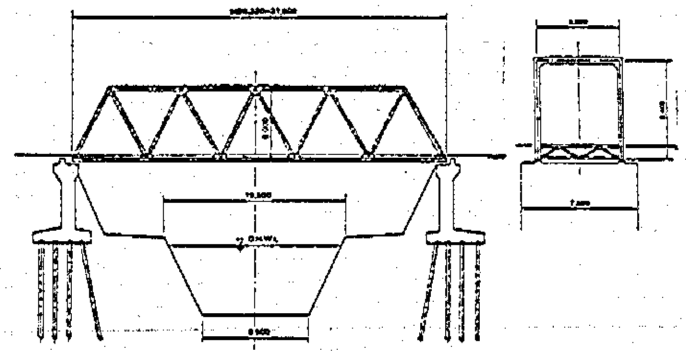
Percut River

No.	Bridge No.	Name of Bridge	Station Number (PE.m)	Length of Bridge and Span (m)				Hight of Beam (m)			Width of Roadway (m)	Nos of Beam				Elevation (EL. m)		Remarks
				Left	Center	Right	Total	Left	Center	Right		Left	Cent.	Right	Total	Riverbed	DHWL	
1	Br.P1	Titi Besi	057 +0 5	25.6	31.6	25.6	82.8	1.25	1.60	1.25	7.0	5	5	5	15	-0.258	5.442	reconstructed
2	Br.P2	Perkebunan	084 + 28	31.6	40.8	31.6	104.0	1.60	1.70	1.60	7.0	5	6	5	16	2.006	7.706	reconstructed
3	Br.P3	Titi Gantung	115 + 05	16.6	-	40.8	57.4	0.90	1.70	-	7.0	5	6		11	4.876	10.576	reconstructed
4	Br.P5	Payung	137 + 45	-	40.8	-	40.8	-	1.70	-	7.0		6		6	7.562	13.672	reconstructed
5	Br.P6	Pedestrian	147 + 58	-	40.8	-	40.8	-	1.70	-	2.0		1		1	8.889	14.999	reconstructed
6	Br.P7	Medan-Tembung	169 + 59	-	40.8	-	40.8	-	1.70	-	9.0		7		7	11.461	17.571	reconstructed
7	Br.P9	Medan -Denai	200 + 25	-	40.8	-	40.8	-	1.70	-	16.0		12		12	15.206	21.316	reconstructed
8	Br.P11	Binjei	222 + 00	-	40.8	-	40.8	-	1.70	-	16.0		12		12	17.847	23.957	reconstructed
9	Br.P13	Amplas	246 + 57.5	-	40.8	-	40.8	-	1.70	-	16.0		12		12	20.828	26.938	reconstructed
10	WBr.1	Water Pipe 1	255 + 10	-		-												dia. 600 (2 pcs)

Medan Floodway

No.	Bridge No.	Name of Bridge	Station Number (FW.m)	Length of Bridge and Span (m)				Hight of Beam (m)			Width of Roadway (m)	Nos of Beam				Elevation (EL. m)		Remarks
				Left	Center	Right	Total	Left	Center	Right		Left	Cen.	Right	Total	Riverbed	DHWL	
11	Br.F1	Jalan Bajak	006 +90	-	31.6	-	31.6	-	1.60	-	7.0	-	6	-	6	25.106	30.906	new
12	Br.F2	PTP IX	020 +45	-	31.6	-	31.6	-	1.60	-	9.0	-	6	-	6	25.682	31.482	new
13	WBr.2	Water Pipe Br	020 +55	-	-	-		-	-	-		-	-	-	-			dia. 800 (1 pcs)
14	WBr.3	Water Pipe Br	024 +90	-	-	-		-	-	-		-	-	-	-			dia. 300 (1 pcs)
15	Br.F3	Jl.STM Ujung	028 +22	-	31.6	-	31.6	-	1.60	-	9.0	-	6	-	6	26.018	32.618	new
16	Br.F4	Keluarga/ Railway	032 +00	-	31.6	-	31.6	-	1.60	-	7.0	-	2	-	2	26.180	31.980	new
17	WBr.4	Water Pipe Br	032 +10	-	-	-		-	-	-		-	-	-	-			dia. 600 & 800
18	Br.F5	Jl.Deli Tua	033 +65	-	31.6	-	31.6	-	1.60	-	16.0	-	10	-	10	26.250	32.050	new
19	Br.F6	Pendestrian Br w/ Water Pipe	037 +60	-	31.6	-	31.6	-	1.60	-	3.0	-	1	-	1	26.420	33.220	dia. 300 (2 pcs)
20	Br.F7	Jl.SMA - 12	38 +78	-	16.6	-	16.6	-	0.90	-	4.5	-	3	-	3	26.470	32.270	new
21	Br.F8	Gg.Seksama	019 + 00*	13.6	31.6	13.6	58.8	0.90	1.60	0.90	2.0		1	-	1	25.289	34.080	reconstructed

Table 4.2.8 COMPARISON OF BRIDGE TYPE FOR RAILWAY BRIDGE

ITEM	PRESTRESSED CONCRETE SINGLE I-GIRDER	WARREN TRUSS STEEL BRIDGE
Typical Features		
Structural Characteristics	[Weight of super structure] Precast PC beams and Concrete Slab : 210 ton [Foundation Pile] : PC Pile Dia.400, L=18m, n=48 - The weight of superstructure of this type is bigger than that of steel truss bridge. - This type is commonly applied for the bridge span of 20 to 40 m.	[Weight of super structure] Steel members and Other metallic materials : 58 ton [Foundation Pile] : PC Pile Dia.400, L=18m, n=40 - Since the superstructure is lighter in weight than PC girder type, a smaller size of substructure can be employed. - Truss type is generally applied for the bridge span of more than 40 m. - For the bridge span of less than 40 m, truss type is more disadvantageous than single T-beam or I-girder types in economy.
Main works and Construction Cost	see below	see below
Availability of materials and Construction Method	- All construction material are available in local market. - Cranes with a high power are necessary for lifting PC girders, but construction period is shorter than truss type bridge.	- Steel members of truss structure will have to be imported. - Building work of the truss can be easy because structural members are light in weight, but it takes longer time than PC girder type.
Maintenance	- Periodical painting is not necessary.	- Periodical (about every 5 years) painting of steel members is required.
Evaluation	Adequate	Inadequate

Main works and Construction Cost — PRESTRESSED CONCRETE SINGLE I-GIRDER

Work	Quantity	(unit)	(Rp)
(1) Excavation	800	m³	5,600,000
(2) Backfill	600	m³	12,000,000
(3) Foundation Pile	864	m	112,320,000
(4) Abutment Concrete	210	m³	84,000,000
(5) PC Girder(31.6 m x 3)	55	m³	93,500,000
(6) PC Concrete Slab and Wall	50	m³	70,000,000
(7) Steel truss Member (Imported)	-	t	-
(8) Shoe	6	pcs.	9,000,000
(9) Ballast	95	m³	4,750,000
(10) Painting	-	l.s.	-
(11) Transportation and Building PC girders	1	l.s.	12,155,000
Total			403,325,000

Main works and Construction Cost — WARREN TRUSS STEEL BRIDGE

Work	Quantity	(unit)	(Rp)
(1) Excavation	720	m³	5,040,000
(2) Backfill	540	m³	10,800,000
(3) Foundation Pile	720	m	93,600,000
(4) Abutment Concrete	180	m³	72,000,000
(5) PC Girder(31.6 m)	-	m³	-
(6) PC Concrete Slab and Wall	-	m³	-
(7) Steel truss Member (Imported)	58	t	348,000,000
(8) Shoe	4	pcs	6,000,000
(9) Ballast	-	m³	-
(10) Painting	1	l.s.	13,920,000
(11) Transportation and Building truss structure	1	l.s.	52,200,000
Total			601,560,000

Table 4.3.1(1/4) AREA AND NUMBER OF BUILDINGS, HOUSES AND AGRICULTURAL CROPS IN THE INUNDATION AREA (DELI RIVER (1))

No.	X	Y	WP (ha)	FL (ha)	PPO (ha)	PGM (ha)	PCC (ha)	POT (ha)	HS (nos)	FA (nos)	SC (nos)	OF (nos)	HP (nos)	RL (nos)
1	1	9	0	25	0	0	0	0	327		3	1		
2	1	10	0	50	0	0	0	0	144		2			
3	2	8	75	0	0	0	0	0	51					
4	2	9	50	0	0	0	0	0	234					
5	2	10	0	0	0	0	0	0	400		1			1
6	2	11	0	25	0	0	0	0	300		1			
7	2	12	0	50	0	0	0	0	39					
8	2	13	0	0	25	0	0	0	148					
9	2	14	0	0	0	0	0	50	2					
10	2	15	0	0	0	0	0	50						
11	2	16	0	0	0	0	0	50						
12	2	17	0	0	0	0	0	100						
13	2	18	0	0	0	0	0	100						
14	2	19	0	0	0	0	0	50	326		1			
15	2	20	0	0	0	0	0	0	100					
16	3	5	0	0	0	0	0	0						
17	3	6	0	0	0	0	0	0						
18	3	7	0	0	0	0	0	0	28					
19	3	8	0	0	0	0	0	0	300	2				
20	3	9	0	0	0	0	0	0	400		2	3		2
21	3	10	0	0	0	0	0	0	400		1			1
22	3	11	0	0	0	0	0	0	400		7			3
23	3	12	0	0	0	0	0	0	312		2			3
24	3	13	0	0	0	0	0	0	400	4	2			2
25	3	14	0	0	0	0	0	0	400	4	5	1		1
26	3	15	0	0	0	0	0	0	400	10				3
27	3	16	0	0	0	0	0	0	500	7	3			3
28	3	17	0	0	0	0	0	25	550	6	3			2
29	3	18	0	0	0	0	0	25	600	2	2			2
30	3	19	0	25	0	0	0	0	344		6			2
31	3	20	0	0	0	0	0	0	700		3			3
32	3	21	0	0	0	0	0	0	250					
33	4	3	0	0	0	0	0	0		5				
34	4	4	0	0	0	0	0	0	49					
35	4	5	0	0	0	0	0	0	100					
36	4	6	0	0	0	0	0	0	14					
37	4	7	0	50	0	25	0	0	89					
38	4	8	0	25	0	0	0	0	339					2
39	4	9	0	0	0	0	0	0	300	4	1			1
40	4	10	0	50	0	0	0	0	100					1
41	4	11	0	0	0	0	0	0	700		3	1		1
42	4	12	0	0	0	0	0	0	550	5	4			2
43	4	13	0	0	0	0	25	0	500	17	1			1
44	4	14	0	0	0	0	0	0	606	38			1	
45	4	15	0	0	0	0	0	0	700	22	6	2		1
46	4	16	0	0	0	0	0	0	1000	16	5			5
47	4	17	0	0	0	0	0	0	850	8	3	2		5
48	4	18	0	0	0	0	0	0	1000	4	3	3		2
49	4	19	0	0	0	0	0	0	1000	2	7	2		3
50	4	20	0	0	0	0	0	0	1000	3	5			4
51	4	21	0	0	0	0	0	0	275					
52	4	22	0	0	0	0	0	0						
53	5	2	0	0	0	0	0	0	850		4			6
54	5	3	0	0	0	0	0	0	700	2		1		1
55	5	4	0	0	0	0	0	0	400	3				1
56	5	5	0	0	0	0	0	0	564		1			1
57	5	6	0	0	0	0	0	0	248		3			3
58	5	7	0	0	0	0	0	0	341	3	4	2		
59	5	8	0	25	25	0	0	0	246		2	3		3
60	5	9	0	50	0	0	0	0	257	3	1	1		1
61	5	10	0	25	25	0	0	0	423	8		1		1

Note: WP : Wet Paddy ; FL : Farm Land ; PPO : Plantation Palm Oil ; PGM : Plantation Rubber ;
PCC : Plantation Cacao ; POT : Plantation Others ; HS : House ; FA : Factory ; SC : School ;
OF : Office ; HP : Hospital ; RL : Mosque & Church

Table 4.3.1(2/4) AREA AND NUMBER OF BUILDINGS, HOUSES AND AGRICULTURAL CROPS IN THE INUNDATION AREA (DELI RIVER (2))

No.	X	Y	WP (ha)	FL (ha)	PPO (ha)	PGM (ha)	PCC (ha)	POT (ha)	HS (nos)	FA (nos)	SC (nos)	OF (nos)	HP (nos)	RL (nos)
62	5	11	0	0	0	0	0	0	700		1			
63	5	12	0	0	0	0	0	0	400	1	1			2
64	5	13	0	0	0	0	25	0	250	1				1
65	5	14	0	0	0	0	0	0	400	4	1			2
66	5	15	0	0	0	0	0	0	550	8	1	1		4
67	5	16	0	0	0	0	0	0	700		3			4
68	5	17	0	0	0	0	0	0	1000		2			
69	5	18	0	0	0	0	0	0	1000	4	3	1		4
70	5	19	0	0	0	0	0	0	1000	5				3
71	5	20	0	0	0	0	0	0	1000	2	2	1		5
72	5	21	0	0	0	0	0	0						
73	5	22	0	0	0	0	0	0						
74	5	23	0	0	0	0	0	0						
75	5	24	0	0	0	0	0	0						
76	6	1	0	0	0	0	0	0	1000	1	8	10		4
77	6	2	0	0	0	0	0	0	408		3			4
78	6	3	0	0	0	0	0	0	201		2			1
79	6	4	0	0	0	0	0	0	4					
80	6	5	0	0	25	0	0	0	42					1
81	6	6	0	0	100	0	0	0						
82	6	7	0	0	50	0	0	0	360		5	1		4
83	6	8	0	0	0	0	0	0	350	1	4			
84	6	9	25	25	0	0	0	0	115		1			1
85	6	10	25	75	0	0	0	0	59		1			
86	6	11	25	0	0	0	0	0	322					
87	6	12	0	0	0	0	0	0	400					1
88	6	13	0	0	0	0	100	0	20					
89	6	14	0	0	0	0	0	0	350	2	1			
90	6	15	0	0	0	0	0	0	350	3	2			1
91	6	16	0	0	0	0	0	0	400	4	3			
92	6	17	0	0	0	0	0	0	700		2			
93	6	18	0	0	0	0	0	0	700	4	3	1		4
94	6	19	0	0	0	0	0	0	1000	1				3
95	6	20	0	0	0	0	0	0						
96	6	21	0	0	0	0	0	0						
97	6	22	0	0	0	0	0	0						
98	6	23	0	0	0	0	0	0						
99	6	24	0	0	0	0	0	0						
100	7	1	0	0	0	0	0	0						
101	7	2	0	0	0	0	0	0						
102	7	3	0	0	0	0	0	0						
103	7	4	0	0	0	0	0	0						
104	7	5	0	0	100	0	0	0						
105	7	6	0	0	75	0	0	0	67		1	1		1
106	7	7	0	0	0	0	0	0	106	1	3			1
107	7	8	0	0	25	0	0	0	169	4				
108	7	9	25	0	75	0	0	0	8					
109	7	10	0	25	0	0	0	0	114					
110	7	11	50	0	0	0	0	0	100					
111	7	12	0	0	0	0	0	0	350					
112	7	13	0	25	0	0	0	0	300					
113	7	14	0	0	0	0	0	25	350		4			
114	7	15	0	0	0	0	0	50	150	2				
115	7	16	0	0	0	0	0	25	142	1				
116	7	17	0	0	0	0	0	0						
117	7	18	0	0	0	0	0	0						
118	7	19	0	0	0	0	0	0						
119	7	20	0	0	0	0	0	0						
120	7	21	0	0	0	0	0	0						
121	7	22	0	0	0	0	0	0						
122	8	1	0	0	0	0	0	0	100	4				2
123	9	1	0	0	0	0	0	0	77	2				
	TOTAL		275	550	525	25	150	550	37,070	233	154	39	1	126

Note : WP : Wet Paddy ; FL : Farm Land ; PPO : Plantation Palm Oil ; PGM : Plantation Rubber ; PCC : Plantation Cacao ; POT : Plantation Others ; HS : House ; FA : Factory ; SC : School ; OF : Office ; HP : Hospital ; RL : Mosque & Church

Table 4.3.1(3/4) AREA AND NUMBER OF BUILDINGS, HOUSES AND AGRICULTURAL CROPS IN THE INUNDATION AREA (PERCUT RIVER (1))

No	X	Y	WP (ha)	FL (ha)	PPO (ha)	PGM (ha)	PCC (ha)	POT (ha)	HS (nos)	FA (nos)	SC (nos)	OF (nos)	HP (nos)	RL (nos)
1	1	19	0	0	0	0	0	0	1000		5			9
2	1	20	0	0	0	0	0	0	1000		11			5
3	1	21	0	0	0	0	0	0	700		1			2
4	1	22	0	0	0	0	0	0	850					2
5	1	23	0	0	0	0	0	0	400					1
6	2	17	0	0	0	0	0	0	1000					
7	2	18	0	0	0	0	0	0	1000		4	1		11
8	2	19	0	0	0	0	0	0	500		7			10
9	2	20	0	0	0	0	0	0	550		4	1		1
10	2	21	0	0	0	0	0	0	500					1
11	2	22	0	0	0	0	0	0	550					1
12	2	23	0	0	0	0	0	0	400					
13	3	8	75	0	0	0	0	0	100					
14	3	9	0	0	0	0	0	50	64					
15	3	10	0	0	0	0	0	100						
16	3	11	0	0	0	0	0	100						
17	3	12	0	0	25	0	0	75	37					
18	3	13	0	0	0	0	0	75	100					
19	3	14	25	0	0	0	0	0	268					
20	3	15	0	0	0	0	75	0	17					
21	3	16	0	0	0	0	25	0	510					
22	3	17	0	0	0	0	0	0	1000					3
23	3	18	0	0	0	0	0	0	1000		5	1		14
24	3	19	0	0	0	0	0	0	700	2	5			3
25	3	20	0	0	0	0	0	0	400		5	1		5
26	3	21	25	0	0	0	25	0	212					
27	3	22	0	0	0	0	25	0	373					
28	3	23	0	0	0	0	0	0	400					
29	4	6	75	0	25	0	0	0	42					2
30	4	7	25	25	0	0	0	0	124		1	1		1
31	4	8	0	50	0	0	50	0	30					
32	4	9	0	0	0	0	0	100	36					
33	4	10	0	0	0	0	0	100						
34	4	11	0	0	0	0	0	100						
35	4	12	0	0	0	0	0	100						
36	4	13	0	0	0	0	0	100						
37	4	14	0	0	0	0	0	0	350		3			
38	4	15	0	0	0	0	100	0	49					
39	4	16	0	0	0	0	50	0	540					
40	4	17	0	0	0	0	0	0	1000					4
41	4	18	0	0	0	0	0	0	500		1	1		4
42	4	19	0	0	0	0	0	25	320		2			2
43	4	20	0	0	0	0	0	100	12					
44	4	21	0	0	0	0	100	0	4					
45	4	22	0	0	0	0	75	0	94					
46	4	23	0	0	0	0	0	0	268	2				1
47	5	4	100	0	0	0	0	0						
48	5	5	100	0	0	0	0	0	43					
49	5	6	100	0	0	0	0	0	126		3			1
50	5	7	25	0	0	0	50	0	169					
51	5	8	0	0	0	0	50	50	2					
52	5	9	0	0	0	0	0	25	300		1			1
53	5	10	0	0	0	0	0	100	31					1
54	5	11	0	0	0	0	0	100						
55	5	12	0	0	0	0	0	75	78					
56	5	13	0	0	25	0	0	50	113		2			
57	5	14	0	25	0	0	25	0	175					
58	5	15	0	0	0	0	25	0	281		1			1
59	5	16	0	0	0	0	25	0	253	5	1			1
60	5	17	0	0	0	0	0	0	550		8			5
61	5	18	0	0	0	0	0	50	241					1
62	5	19	0	0	0	0	0	100	20					
63	5	20	0	0	0	0	0	75						
64	6	3	25	0	0	0	0	0						
65	6	4	50	0	0	0	0	0						
66	6	5	100	0	0	0	0	0						
67	6	6	100	0	0	0	0	0	86		2			
68	6	7	25	0	0	0	25	0	236					1
69	6	8	0	0	0	0	25	25	200					1
70	6	9	0	0	0	0	0	0	400	1	4	2		2
71	6	10	0	0	0	0	0	100	38					
72	6	11	0	0	0	0	0	50	106		2			1
73	6	12	0	0	0	0	0	75	78					2
74	6	13	0	25	0	0	0	0	175	1	1	1		
75	6	14	0	0	0	0	0	0	300		4			3
76	6	15	0	0	0	0	0	0	400	4	1	1		
77	6	16	0	0	0	0	0	0	400	7	4			5
78	6	17	0	0	0	0	0	0	700		2			1
79	6	18	0	0	0	0	0	50	184					
80	7	1	0	25	0	0	0	0						

Note: WP : Wet Paddy ; FL : Farm Land ; PPO : Plantation Palm Oil ; PGM : Plantation Rubber ;
PCC : Plantation Cacao ; POT : Plantation Others ;HS : House ; FA : Factory ; SC : School ;
OF : Office ; HP : Hospital ; RL : Mosque & Church

Table 4.3.1(4/4) AREA AND NUMBER OF BUILDINGS, HOUSES AND AGRICULTURAL CROPS IN THE INUNDATION AREA (PERCUT RIVER (2))

No	X	Y	WP (ha)	FL (ha)	PPO (ha)	PGM (ha)	PCC (ha)	POT (ha)	HS (nos)	FA (nos)	SC (nos)	OF (nos)	HP (nos)	RL (nos)
81	7	2	0	75	0	0	0	0	32					
82	7	3	0	0	0	0	0	0						
83	7	4	25	0	0	0	0	0						
84	7	5	100	0	0	0	0	0						
85	7	6	100	0	0	0	0	0	55		1			
86	7	7	25	0	0	0	0	0	326		3			1
87	7	8	25	25	0	0	0	0	203		1			
88	7	9	0	25	0	0	0	25	201		1			
89	7	10	0	25	0	0	0	75						
90	7	11	0	50	0	0	0	0	144		1			
91	7	12	0	0	0	0	0	50	141					
92	7	13	0	0	0	0	0	100						
93	7	14	25	0	0	0	0	50	144					
94	7	15	0	0	0	0	0	0	500	1	2	1		1
95	7	16	0	0	0	0	0	0	700		2			3
96	7	17	0	0	0	0	0	0	400	1	1			
97	7	18	50	0	0	0	0	0	64					
98	8	1	0	50	0	0	0	0	17					
99	8	2	0	50	0	0	0	0	47					
100	8	3	0	0	0	0	0	0						
101	8	4	0	0	25	0	0	0	19					
102	8	5	25	25	25	0	0	0	77	3				
103	8	6	50	0	0	0	0	0	148		2			1
104	8	7	25	0	0	0	0	0	236		4			4
105	8	8	50	0	0	0	0	50	2					
106	8	9	0	0	0	0	0	100						
107	8	10	0	0	0	0	0	100						
108	8	11	75	0	0	0	0	0	126		1			2
109	8	12	25	0	0	0	0	25	163		1			1
110	8	13	0	0	0	0	0	75	68		1			1
111	8	14	0	25	0	0	0	75	78					
112	8	15	0	0	0	0	0	0	210	1	1			1
113	8	16	50	0	0	0	0	0	282		2			1
114	8	17	0	0	0	0	0	0	550	1	2			
115	9	2	0	0	0	0	0	0						
116	9	3	0	0	0	0	0	0	58					
117	9	4	25	0	0	0	0	0	92					
118	9	5	75	0	25	0	0	0	15					
119	9	6	100	0	0	0	0	0						
120	9	7	50	0	0	0	0	0	139		1			1
121	9	8	100	0	0	0	0	0	14					
122	9	9	0	0	0	0	0	100	35					
123	9	10	0	0	0	0	0	100						
124	9	11	0	0	0	0	0	50	70					
125	9	12	25	0	0	0	0	0	208	1	3			1
126	9	13	0	0	25	0	0	0	75					1
127	9	14	0	0	0	0	0	0						
128	9	15	25	0	0	0	0	0	150		1			
129	9	16	75	0	0	0	0	0	120		3			
130	9	17	0	0	0	0	0	0	129					
131	10	3	0	0	0	0	0	0			1			2
132	10	4	0	0	0	0	0	0	2					1
133	10	5	75	0	0	0	0	0						
134	10	6	75	0	0	0	0	0	136		1			
135	10	7	100	0	0	0	0	0	69					
136	10	8	100	0	0	0	0	0	52					
137	10	9	50	0	0	0	0	50						
138	10	10	0	0	0	0	0	100						
139	10	11	50	0	0	0	0	50						
140	10	12	25	0	0	0	0	0	189					1
141	10	13	50	0	0	0	0	0	104					1
142	10	14	25	0	0	0	0	0	197		1			
143	10	15	50	0	0	0	0	0	134		2			
144	10	16	50	0	0	0	0	0	122	2				
145	11	3	0	0	0	0	0	0	7					
146	11	4	0	0	0	0	0	0						
147	11	5	100	0	0	0	0	0						
148	11	6	75	0	0	0	0	0	81		1			2
149	11	7	100	0	0	0	0	0	13					1
150	11	8	75	0	0	0	0	0	1					
151	12	3	0	0	0	0	0	0						
152	12	4	0	0	0	0	0	0						
153	12	5	50	25	0	0	0	0						
154	13	3	0	0	0	0	0	0						
155	13	4	0	0	0	0	0	0						
156	13	5	0	0	0	0	0	0						
TOTAL			3025	525	175	0	750	3125	29,830	32	130	11	0	136

Note : WP : Wet Paddy ; FL : Farm Land ; PPO : Plantation Palm Oil ; PGM : Plantation Rubber ;
PCC : Plantation Cacao ; POT : Plantation Others ;HS : House ; FA : Factory ; SC : School ;
OF : Office ; HP : Hospital ; RL : Mosque & Church

Table 4.3.2 APPRAISAL VALUE OF ASSETS

1. Buildings and Household Effects

(Unit : Rp. Million)

Item No.	Kind of Asset	Buildings	House-hold Effects
1	Residence	10.30	5.70
2	Shop	19.80	15.10
3	Office	273.00	145.70
4	School	156.00	19.40
5	Hospital	117.00	23.30
6	Factory	117.00	48.50
7	Mosque/Church	58.50	7.70

2. Agricultural Crops

Item No.	Crops	Production (Tons/ha)	Unit Price (M-Rp/ton)	Unit Price (M-Rp/ha)
1	Paddy (wetland)	4.30	0.472	2.032
2	Paddy (dry land)	2.20	0.472	1.039
3	Rubber	0.50	0.197	0.098
4	Coconut	0.82	0.140	0.115
5	Palm oil	2.20	0.945	2.079
6	Palm kernel	0.32	0.553	0.177
7	Cacao	0.62	2.837	1.759
8	Tobacco	0.53	5.915	3.135
9	Maize	2.42	0.200	0.485
10	Cassava	13.20	0.090	1.191
11	Potato	10.10	0.135	1.362
12	Peanut	1.14	0.782	0.892
13	Soybean	1.08	1.004	1.084
14	Green pea	0.96	1.311	1.258

Table 4.3.3 DAMAGE RATE TO SUBMERGED ASSETS

(1) Buildings

Water Level Above Floor (meter)	Damage Rate (%)
0.00 - 0.49	0.037
0.50 - 0.99	0.064
1.00 - 1.49	0.099
1.50 - 1.99	0.137
2.00 - 2.49	0.179

(2) Household Effects

Buildings	Water Level Above Floor (meter)						
	0 - 0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2.0	2.0 - 2.5	2.5 - 3.0	over 3.0
Residential	0.407	0.600	0.642	0.622	0.683	0.690	0.690
Shop	0.251	0.448	0.543	0.561	0.579	0.597	0.597
Office, etc. (1	0.411	0.575	0.613	0.626	0.632	0.632	0.632

(1 : Office, school, hospital, factory, mosque, churth and kiosk.

(3) Paddy

(Unit : %)

Submergence Depth	Duration (day)	Tillering Stage 0 - 70 th day (0 - 54 %)	Booling Stage 71 - 87 th day (55 - 67 %)	Heading Stage 88 - 100 th day (68 - 77 %)	Ripening Stage 101 - 130 th day (78 - 100 %)
Case (A)	1 to 2	10	70	30	5
Over	3 to 4	20	80	80	20
Plant	5 to 6	30	85	90	30
Height	Over 7	35	95	100	30
Case (B)	1 to 2	6	40	10	4
75% of	3 to 4	9	46	23	15
Plant	5 to 6	14	49	26	23
Height	Over 7	16	55	30	23
Case (C)	1 to 2	4	37	8	2
50% of	3 to 4	9	42	22	4
Plant	5 to 6	13	45	25	6
Height	Over 7	15	50	28	6

(4) Tree Crops

Inundation Depth (m)	Damage Rate (%)
0.00 - 0.49	5
0.50 - 0.99	10
1.00 - 1.49	20
1.50 - 1.99	40
2.00 - 2.49	80
over 2.50	100

(5) Upland Crops

Inundation Depth (m) Depth (m)	Duration (days)	Damage Rate (%)
0.00 - 0.49	3 - 5	35
0.50 - 0.99	4 - 6	67
1.00 - 1.49	5 - 7	85
1.50 - 1.99	5 - 7	95
2.00 - 2.49	over 7	99

Table 4.3.4 SUMMARY OF FLOOD DAMAGE

- Deli River -

(Unit : Rp. Million)

Return Period	Wet Paddy	Farmland	Plantation				Residence	Factory	School	Office	Hospital	Mosque/ Church	Public Structures	Business Loss	TOTAL
			Palm Oil	Rubber	Cacao	Other									
110	15.24	109.87	0.52	0.02	2.20	17.59	111,516.90	4,660.63	1,975.41	2,662.08	0.00	738.59	41,328.23	72,932.17	235,959.45
70	13.21	106.89	0.52	0.02	2.20	17.59	107,775.09	4,147.11	1,892.14	2,494.74	0.00	711.49	39,786.99	70,212.34	227,160.33
40	13.21	106.89	0.52	0.02	2.20	17.59	100,885.67	3,955.47	1,799.97	2,439.03	0.00	672.07	37,315.75	65,851.33	213,059.72
25	13.21	106.89	0.52	0.02	2.20	15.39	95,035.66	3,664.62	1,588.52	2,135.07	0.00	650.56	35,045.30	61,844.65	200,102.61
12	13.21	106.89	0.52	0.02	0.00	13.19	81,548.32	3,249.11	1,259.88	1,771.40	0.00	543.75	30,046.64	53,023.48	171,576.41
6	13.21	82.48	0.52	0.02	0.00	13.19	79,252.21	3,000.96	1,232.24	1,707.85	0.00	530.49	29,146.07	51,434.25	166,413.49
2	13.21	72.95	0.52	0.02	0.00	13.19	57,919.74	2,145.42	956.12	1,198.12	0.00	379.97	21,283.79	37,559.62	121,542.67

- Percut River -

(Unit : Rp. Million)

Return Period	Wet Paddy	Farmland	Plantation				Residence	Factory	School	Office	Hospital	Mosque/ Church	Public Structures	Business Loss	TOTAL
			Palm Oil	Rubber	Cacao	Other									
110	412.50	52.11	1.56	0.00	8.80	118.73	22,090.55	98.80	331.01	0.00	0.00	189.98	7,721.51	1,362.62	32,388.17
70	412.50	52.11	1.56	0.00	4.40	101.14	20,068.74	98.80	331.01	0.00	0.00	189.98	7,034.09	1,241.31	29,535.64
40	396.24	41.69	1.56	0.00	4.40	87.95	19,551.63	98.80	321.75	0.00	0.00	182.81	6,852.70	1,209.30	28,748.83
25	381.51	31.26	1.04	0.00	4.40	87.95	19,036.57	24.70	321.75	0.00	0.00	179.23	6,651.16	1,173.74	27,893.31
12	353.06	31.26	1.04	0.00	2.20	83.55	14,195.45	24.70	303.37	0.00	0.00	136.21	4,984.31	879.58	20,994.73
5	346.46	31.26	1.04	0.00	2.20	76.96	12,847.43	24.70	238.97	0.00	0.00	125.46	4,500.43	794.19	18,989.10

Table 4.3.5 ECONOMIC EVALUATION OF MEDAN FLOOD CONTROL PROJECT

I. Immediate Plan (Return Period : 25 Years)

(Unit : Rp Million)

	Year	Economic Cost			Economic	(B)-(C)
		Construction	OM	Total (C)	Benefit (B)	
1	1998	15,270	0	15,270	0	-15,270
2	1999	52,980	0	52,980	0	-52,980
3	2000	65,948	474	66,422	7,119	-59,303
4	2001	44,193	948	45,141	14,737	-30,404
5	2002		1,319	1,319	22,897	21,578
6	2003		1,319	1,319	23,584	22,265
7	2004		1,319	1,319	24,291	22,972
8	2005		1,319	1,319	25,020	23,701
9	2006		1,319	1,319	25,771	24,452
10	2007		1,319	1,319	26,544	25,225
11	2008		1,319	1,319	27,340	26,021
12	2009		1,319	1,319	28,160	26,841
13	2010		1,319	1,319	29,005	27,686
14	2011		1,319	1,319	29,875	28,556
15	2012		1,319	1,319	30,772	29,453
16	2013		1,319	1,319	31,695	30,376
17	2014		1,319	1,319	32,646	31,327
18	2015		1,319	1,319	33,625	32,306
19	2016		1,319	1,319	34,634	33,315
20	2017		1,319	1,319	35,673	34,354
21	2018		1,319	1,319	36,743	35,424
22	2019		1,319	1,319	37,845	36,526
23	2020		1,319	1,319	38,981	37,662
24	2021		1,319	1,319	40,150	38,831
25	2022		1,319	1,319	41,355	40,036
26	2023		1,319	1,319	42,595	41,276
27	2024		1,319	1,319	43,873	42,554
28	2025		1,319	1,319	45,189	43,870
29	2026		1,319	1,319	46,545	45,226
30	2027		1,319	1,319	47,941	46,622
31	2028		1,319	1,319	49,379	48,060
32	2029		1,319	1,319	50,861	49,542
33	2030		1,319	1,319	52,387	51,068
34	2031		1,319	1,319	53,958	52,639
35	2032		1,319	1,319	55,577	54,258
36	2033		1,319	1,319	57,244	55,925
37	2034		1,319	1,319	58,962	57,643
38	2035		1,319	1,319	60,731	59,412
39	2036		1,319	1,319	62,552	61,233
40	2037		1,319	1,319	64,429	63,110
41	2038		1,319	1,319	66,362	65,043
42	2039		1,319	1,319	68,353	67,034
43	2040		1,319	1,319	70,403	69,084
44	2041		1,319	1,319	72,515	71,196
45	2042		1,319	1,319	74,691	73,372
46	2043		1,319	1,319	76,932	75,613
47	2044		1,319	1,319	79,240	77,921
48	2045		1,319	1,319	81,617	80,298
49	2046		1,319	1,319	84,065	82,746
50	2047		1,319	1,319	86,587	85,268
51	2048		1,319	1,319	89,185	87,866
52	2049		1,319	1,319	91,860	90,541
53	2050		1,319	1,319	94,616	93,297
54	2051		1,319	1,319	97,455	96,136
55	2052		1,319	1,319	100,378	99,059
56	2053		1,319	1,319	103,390	102,071
	Total	178,391	70,010	248,401	2,808,334	2,559,933

EIRR (%) 14.42

Discount	B/C	PV (Rp. Million)		NPV
Rate (%)		Cost	Benefit	(Rp Million)
15	0.95	127,846	121,848	-5,998
12	1.25	138,801	174,041	35,240
10	1.57	147,348	231,513	84,164

II. Urgent Plan (Return Period : 40 Years)

(Unit : Rp Million)

	Year	Economic Cost			Economic	(B)-(C)
		Construction	OM	Total (C)	Benefit (B)	
1	1998	15,270	0	15,270	0	-15,270
2	1999	53,223	0	53,223	0	-53,223
3	2000	72,410	595	73,005	9,407	-63,598
4	2001	47,541	1,268	48,809	20,751	-28,058
5	2002	3,348	1,497	4,845	25,351	20,506
6	2003	3,348	1,532	4,880	26,726	21,846
7	2004		1,566	1,566	28,140	26,574
8	2005		1,566	1,566	28,984	27,418
9	2006		1,566	1,566	29,854	28,288
10	2007		1,566	1,566	30,749	29,183
11	2008		1,566	1,566	31,672	30,106
12	2009		1,566	1,566	32,622	31,056
13	2010		1,566	1,566	33,601	32,035
14	2011		1,566	1,566	34,609	33,043
15	2012		1,566	1,566	35,647	34,081
16	2013		1,566	1,566	36,716	35,150
17	2014		1,566	1,566	37,818	36,252
18	2015		1,566	1,566	38,952	37,386
19	2016		1,566	1,566	40,121	38,555
20	2017		1,566	1,566	41,325	39,759
21	2018		1,566	1,566	42,564	40,998
22	2019		1,566	1,566	43,841	42,275
23	2020		1,566	1,566	45,156	43,590
24	2021		1,566	1,566	46,511	44,945
25	2022		1,566	1,566	47,906	46,340
26	2023		1,566	1,566	49,344	47,778
27	2024		1,566	1,566	50,824	49,258
28	2025		1,566	1,566	52,349	50,783
29	2026		1,566	1,566	53,919	52,353
30	2027		1,566	1,566	55,537	53,971
31	2028		1,566	1,566	57,203	55,637
32	2029		1,566	1,566	58,919	57,353
33	2030		1,566	1,566	60,686	59,120
34	2031		1,566	1,566	62,507	60,941
35	2032		1,566	1,566	64,382	62,816
36	2033		1,566	1,566	66,314	64,748
37	2034		1,566	1,566	68,303	66,737
38	2035		1,566	1,566	70,352	68,786
39	2036		1,566	1,566	72,463	70,897
40	2037		1,566	1,566	74,637	73,071
41	2038		1,566	1,566	76,876	75,310
42	2039		1,566	1,566	79,182	77,616
43	2040		1,566	1,566	81,558	79,992
44	2041		1,566	1,566	84,004	82,438
45	2042		1,566	1,566	86,524	84,958
46	2043		1,566	1,566	89,120	87,554
47	2044		1,566	1,566	91,794	90,228
48	2045		1,566	1,566	94,548	92,982
49	2046		1,566	1,566	97,384	95,818
50	2047		1,566	1,566	100,306	98,740
51	2048		1,566	1,566	103,315	101,749
52	2049		1,566	1,566	106,414	104,848
53	2050		1,566	1,566	109,607	108,041
54	2051		1,566	1,566	112,895	111,329
55	2052		1,566	1,566	116,282	114,716
56	2053		1,566	1,566	119,770	118,204
	Total	195,140	83,192	278,332	3,256,339	2,978,007

EIRR (%) 15.43

Discount	B/C	PV (Rp.Million)		NPV
Rate (%)		Cost	Benefit	(Rp Million)
15	1.03	138,459	143,179	4,720
12	1.35	150,856	203,812	52,956
10	1.68	160,582	270,512	109,930